



ALTERNATIVE ENERGY
AND
CONSERVATION DEMONSTRATIONS

PROJECT REPORT



Canada

COMMERCIAL, INDUSTRIAL & INSTITUTIONAL
WOOD ENERGY CONVERSION
GUIDE

Prince Edward Island Project No. 02208

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Managing Canada's energy effectively in the 1980's and beyond requires us to use innovative energy conservation and alternative energy technologies. Demonstrating these energy solutions in real-life situations is essential to establish their commercial viability and convince consumers of their advantages.

ENERDEMO-Canada, a program of Energy, Mines and Ressources Canada, assists demonstration projects and helps to transfer the results of these demonstrations to potential suppliers and users in order to accelerate the adoption and commercial use of energy conservation, oil substitution and alternative energy technologies and to create business opportunities and employment in new or existing industries.

This final report is based on a project which was supported by the program. For additional information, contact your local EMR Canada office.

SUMMARY

This guide is designed for owners and managers of commercial, industrial and institutional facilities located in Prince Edward Island, to help determine the potential economic benefit of converting existing building oil heating systems to heating systems which burn wood.

In deciding to convert to wood, several steps to follow are suggested and described to simplify the decision process. Three of these are noted as essential: analysis of current heating system and future heating requirements; identification of an appropriate wood fuelled system; and assessment of wood supply, technical and economic factors and risk. In addition to these steps, considerable attention should be directed towards wood fuel supply, storage and handling, and heating system operation which differ substantially from conventional oil heating systems.

This guide also compares round-wood and wood chip/residue fed systems, discusses wood supply and provides information on purchasing and installation of a suitable furnace or boiler system. It is noted that fuel savings of at least 45 percent are achievable with hardwood sawlogs and, based on a typical situation, fuel savings of 40 to 80 percent are attainable with wood chips. Experience has shown that the highest returns on investment, especially for wood chip systems, come from sizing the equipment to provide the base, rather than the peak, load requirements. After-grant pre-tax pay-backs of sample round-wood and woodchip installation range from 2.1 to 9.0 years.

In determining how economical a possible conversion will be, the volume of wood fuel to be used, the cost of the fuel in a form ready to use and the capital investment required will have the greatest influence on the decision. At this point, an additional factor which should also be considered when choosing between a round-wood or woodchip burning system is the method of feeding the wood fuel. Round-wood burning systems are generally fed manually, while wood chip/residue burning systems are usually installed with an automatic chip feeding system. The round-wood system is the preferable route if no value is attributed to maintenance and feeding labour. However, institutions and businesses that have no staff capable of loading large volumes of round-wood are better served by an automated system. Experience suggests that the decision is based on the individual's preference at each site to make use of a labour intensive system, or to make use of an automatic, capital intensive system.

The most readily available source of wood fuel is in the form of residue from forest products. Because of their high cost, sawlogs are not recommended as fuel. Additionally, harvest levels on the Island of fuel in this form may be at or beyond the sustainable level. Low grade hardwood and low grade pulp wood are wood products with good fuel potential. In terms of price, pulp wood sold through a supply infrastructure can be obtained at approximately \$27/tonne delivered for 2.5 m lengths; woodchips can be purchased from at least four Island contractors at \$30 to \$40/tonne delivered, and sawmill wastes can be purchased from a number of sawmills on the Island at \$9 - 25/tonne delivered.

Turnkey installations are available from larger equipment suppliers. In many ways, this is desirable since the responsibility for equipment installation is assumed by the manufacturer who is experienced in the area. Installations of this type already exist on the Island among other successful wood fuelled projects funded by the provincial and the federal governments. Currently, the principal government incentive program for organizations considering investing in a wood fuelled heating plant is the Alternate Energy Development Program (AEDP) administered by EMR Canada.

ENERDEMO-Canada

Pour bien gérer ses ressources énergétiques dans les années 80 et au-delà, le Canada devra faire appel à des techniques innovatrices en matière d'économie d'énergie et d'énergies de rechange. Il est nécessaire de faire la démonstration de ces nouvelles techniques dans des conditions réelles si l'on veut établir leur viabilité commerciale et convaincre le consommateur de leurs avantages.

Dans le cadre d'ENERDEMO-Canada, Energie, Mines et Ressources Canada fournit un soutien aux promoteurs de projets de démonstration et aide à diffuser les résultats de ces projets aux fournisseurs et utilisateurs éventuels, afin de favoriser l'adoption et la mise en marché des techniques relatives aux économies d'énergie, au remplacement du pétrole et aux énergies de rechange et de susciter des occasions d'affaires et des emplois dans des industries nouvelles ou existantes.

Ce rapport finale est basé sur un projet supporté par le programme. Pour plus de renseignements, communiquez avec le bureau d'EMR Canada le plus rapproché.

RESUME

Le présent guide a pour but d'aider les propriétaires et les administrateurs d'établissements commerciaux, industriels et autres de l'Ile-du-Prince-Edouard à déterminer la possibilité de convertir leurs systèmes de chauffage au mazout en systèmes fonctionnant au bois.

Pour simplifier la prise d'une décision à cet égard, le guide propose et décrit plusieurs étapes à suivre. Trois d'entre elles sont essentielles: examiner les installations actuelles et les besoins prévus en chauffage, déterminer quelles installations au bois conviendraient et examiner la question de l'approvisionnement en bois, les facteurs techniques et économiques en jeu et les risques. Au fil de ces étapes, les intéressés doivent tenir compte des différences importantes qui existent entre les installations de chauffage au bois et les installations de chauffage au mazout, en ce qui a trait à l'approvisionnement en combustible, au stockage et à la manutention de ce combustible et au fonctionnement des installations de chauffage.

Le guide compare les installations au bois rond et aux copeaux et déchets, examine la question de l'approvisionnement en bois et procure des renseignements sur l'acquisition et l'installation d'une fournaise ou chaudière appropriée. On y signale que des économies de combustible allant jusqu'à au moins 45% sont réalisables, grâce à l'utilisation des grumes de feuillus et que les économies de combustible peuvent atteindre entre 40 et 80%, dans le cas des copeaux. L'expérience démontre que l'investissement est plus rentable lorsque l'on choisit la taille de la chaudière en fonction des besoins de base et non des besoins maximaux, en particulier dans le cas des installations fonctionnant aux copeaux. La période de recouvrement des coûts, en ce qui concerne les installations au bois rond et aux copeaux examinées, va de 2,1 à 9 ans, si l'on tient compte des subventions mais non des taxes.

Les principaux facteurs à soupeser pour déterminer l'importance des économies réalisables et prendre une décision à cet égard sont la quantité de bois à utiliser, le coût du combustible sous une forme prête à utiliser et les montants à investir. À ces facteurs s'ajoutent le choix de la méthode d'alimentation en bois lorsque vient le moment de choisir entre un système fonctionnant au bois rond et un système aux copeaux. En général, les installations au bois rond sont chargées manuellement et les installations au copeaux et aux résidus le sont à l'aide d'un système de chargement automatique. Les installations au bois rond sont préférables lorsque les frais d'entretien et de main-d'oeuvre ne posent pas de problèmes. Toutefois, les établissements et les entreprises qui ne disposent pas de la main-d'oeuvre voulue pour s'occuper du chargement de quantités importantes de bois rond y gagneraient à s'intéresser aux systèmes de chargement automatique. L'expérience démontre que l'on prend la décision, soit d'acquérir des installations nécessitant une bonne part de main-d'oeuvre soit de se doter d'installations automatiques nécessitant un investissement important, selon ce qui semble préférable à chaque endroit.

C'est sous forme de déchets de produits forestiers que l'on peut se procurer le plus aisément du bois de chauffage. Vu que les grumes sont d'un coût élevé, il n'est pas recommandé de les utiliser. D'ailleurs, il se peut que le niveau de production des grumes à l'Ile-du-Prince-Edouard ait atteint, voire dépassé le seuil de régénération naturelle. Les bois de feuillus et de trituration de qualité inférieure ont un bon potentiel énergétique. Côté prix, on peut se procurer du bois de trituration auprès d'un fournisseur, en pièces de 2,5 m, pour environ 27\$ la tonne; les copeaux peuvent être achetés à au moins 4 entrepreneurs insulaires pour 30\$ à 40\$ la tonne livrée et les déchets de sciage peuvent être achetés à un certain nombre de scieries établies sur l'Ile, pour 9\$ à 25\$ la tonne livrée.

On peut se procurer des installations clés en main auprès des grands fournisseurs de matériel. Cette option est très intéressante, car la responsabilité d'installer le matériel incombe au fabricant et ce dernier possède de l'expérience dans le domaine. Des installations de ce genre ont déjà été mises en place sur l'Ile, dans le cadre d'autres projets d'utilisation du bois comme combustible, subventionnés avec succès par les gouvernements provincial et fédéral. A l'heure actuelle, le principal programme de subvention qui s'adresse aux organismes qui envisagent de se doter d'une chaufferie au bois est le Programme de mise en valeur des énergies de remplacement, administré par Energie, Mines et Ressources Canada.

Definitions and Nomenclature

Bhp	Boiler Horsepower
Btu	British Thermal Unit
Cd	Cords
Ha	Hectare
J	Joule
Kg	Kilogram
M	Metre
MW	Megawatt
KW	Kilowatt
T	Ton
t	Metric Tonne

Conversion Factors

Acre	x 0.4046856	= Hectare
Bhp	x 9.8095	= KW
Btu/hr	x 0.00029065	= KW
Gallons (Imp)	x 4.5459	= Litres
Kilogram	x 2.2046226	= Pounds
Ton	x 0.90718474	= Metric tonne

Part 1: Purpose of This Guide

Approximately two out of every three households on Prince Edward Island burn wood for some or all of their residential heating requirements. The main reason that people burn wood at home is to save money. Depending on the amount of oil displaced and the cost of wood burned, savings of many hundreds of dollars can be realized. These savings usually provide for a very attractive return on the homeowner's investment in a wood stove or central heating system.

In contrast to the widespread acceptance of the use of wood fuel among P.E.I. homeowners, conversions to wood fuel in commercial, industrial and institutional facilities have only recently begun to be made. The reasons for the slower rate of conversion to wood at these facilities include:

- Proven designs which incorporate appropriately-sized wood fuelled equipment have only recently become available.
- Wood chips and other types of wood fuel have only just become increasingly available.
- Few conversions are available to demonstrate how businesses and institutions can experience the reliability as well as economy of wood fuelled systems.
- A new capital assistance program was introduced by Energy Mines and Resources Canada (EMR) in early 1985 to significantly reduce the investment cost for qualifying conversion projects (see section 6.0).

The purpose of this guide is to help owners and managers of commercial, industrial and institutional facilities which burn large quantities of oil determine whether conversion to wood fuel makes sense for them. In Part 2 of this guide, the steps involved in deciding whether conversion to wood would be desirable are described. This description highlights the differences between heating with oil and wood and identifies the major considerations associated with conversion to wood. Part 2 then provides some "rules of thumb" for estimating the financial attractiveness of converting to wood.

The remainder of this guide provides more detailed information on topics that may be of particular interest to different readers depending on their level of knowledge and experience with wood burning and the nature of the physical and operating characteristics of the facilities in which they are interested. Part 3 discusses the advantages and disadvantages of roundwood compared to wood chip heating systems. Part 4 addresses the issues surrounding the procurement of wood fuel while Part 5 describes available combustion equipment and the process of buying and installing heating systems.

In Part 6, current government programs are described, with particular attention to EMR's "Alternate Energy Demonstration Program". Part 7 outlines an approach for assessing the financial attractiveness of possible investments in wood fired systems. The final section of this guide, Part 8, provides references for obtaining further information.

Part 2: Deciding to Convert to Wood

A number of facilities on P.E.I., such as the Kings County Hospital and the Royalty Gardens Greenhouse, have been successfully converted from oil to wood fuelled heating systems. In order to ensure that conversions will prove successful, it is essential that three main steps be followed in the evaluation of conversion alternatives:

- Step 1:** Understand the configuration and costs associated with the current heating system and the likely requirements for heat over the next 5 - 10 years.
- Step 2:** Identify the alternative wood fuelled systems that can meet these requirements.
- Step 3:** Assess these alternatives from the standpoint of wood fuel supply factors, technical considerations, economic factors and risk.

As these steps are followed, it should be kept in mind that conversion to wood fuel involves conversion to an entirely new system for providing useful heat for a facility. Thus, the full range of factors that are affected by a conversion must be recognized and the impact of conversion on each step must be anticipated. In particular, three major differences from the current heating system must be understood:

- **WOOD SUPPLY:** The procurement of a reliable supply of good quality wood fuel can be considerably more complicated than arranging for the automatic delivery of oil.
- **WOOD FUEL STORAGE AND HANDLING:** Wood fuel is bulky and can be difficult to store and move to the combustion equipment.

- **OPERATION:** The loading of wood fuel, the maintenance of wood burning equipment, and the removal of ash will involve more work and cost than is required by automated oil systems.

Because of these three differences, the conversion to a wood fuelled system typically requires additional time to manage and operate, additional space for fuel storage and new equipment in order to realize the potentially substantial fuel cost savings. As noted above, the first step involved in considering the feasibility and desirability of conversion to wood fuel is to put together a clear picture of the current picture of the existing heating system. This picture has two main components:

- a) Identification of how much oil is currently being used for space heat, process heat and domestic hot water requirements. Any expected changes in these requirements during the next 5 - 10 years should also be identified.
- b) Assessment of the current system to determine its configuration and its condition. It usually proves useful, if not essential, during the planning process to have available a floor plan, heating system schematic and up-to-date building drawings. Because a new wood fuelled system can delay the replacement of an existing boiler, it is important to assess the condition of the current system.

The second step to be carried out, when considering the conversion of a facility to wood fuel, involves the identification of possible heating systems that can meet the facility's requirements. The first choice to be made is between

equipment which burns roundwood and equipment which burns wood chips or sawmill residue such as sawdust. While roundwood equipment is less expensive, wood chip equipment offers the convenience of automatic feeding for periods of 24 hours or more. Other advantages and limitations of each type of system are discussed in Part 3 of this guide, while Part 4 discusses fuel procurement for roundwood and wood chips. Part 5 describes specific equipment choices and the approach for assessing these choices from the perspective of technical feasibility.

After identification of the wood fuelled system or systems that may meet the facility's requirements, the third step in the evaluation process takes place. This step involves:

- * An assessment of all relevant fuel supply factors, including:
 - Accessibility and security of wood fuel supply.
 - Method for storage and handling of wood fuel.
 - Cost and moisture content of wood fuel, delivered and ready to burn.
- * An assessment of all relevant technical factors, including:
 - Confirmation of feasibility -- the system will work as expected in the proposed configuration.
 - Identification of electricity, maintenance labour, insurance and other costs necessary to operate the system.
 - Confirmation of the capital investment to design, install and start up the system.
 - Identification of measures required:
 - a) to ensure long-term safe operation of the system; and,

- b) to be sensitive to possible environmental concerns regarding storage of wood fuel and stack emissions.

- * An assessment of relevant economic factors to determine whether conversion to wood is financially attractive including:

- Calculation of fuel cost savings.
- Identification of the capital investment required (for heating equipment, buildings and, where applicable, a substantial inventory of wood fuel) before and after appropriate government contributions.
- Identification of any increase in labour and maintenance costs.
- Calculation of payback and return on investment measures relevant to the business or institution operating the facility.

- * An assessment of major risks associated with conversion to a wood fuelled system, including:

- Anticipated reliability of equipment.
- Assurance of fuel supply and costs.
- Safety of operation.
- Stability of future heating requirements.
- Availability of capital required for the conversion.
- Anticipated maintenance and repair costs.

The outcome of this detailed assessment step determines which system (if any) is the most technically and financially feasible and attractive for conversion to wood fuel. With this determined, the management of the facility can seek the necessary

approvals to make the investment and then initiate the commitments to purchase the system and obtain a supply of wood fuel.

The decision to convert to a wood fuelled system involves a decision to make a capital investment in equipment (and possibly working capital) in order to achieve lower heating costs. To realize savings, the time, effort and expense of buying, storing and handling wood and maintaining the system must be compared to the cost of continuing to burn oil to determine whether the net savings represent an attractive return on investment. While it must be emphasized that each potential conversion site is unique, it is possible to provide a few rules of thumb regarding the economics of conversion to a wood fuelled system.

1. Fuel Savings - Roundwood

Typically, a cord of well seasoned hardwood will displace around 400 - 500 litres of oil. If oil costs 33 ¢/litre and hardwood (blocked and delivered) costs \$80/cord, fuel savings of at least 45 percent are achievable. To calculate savings at different oil prices and wood costs use the following formulas

$$\text{Savings (\$/litre)} = \text{Oil Cost (\$/litre)} - \text{Wood Cost (\$/cord)}/450$$

2. Fuel Savings - Wood Chips/Residue

The cost of fuel for wood chip systems can vary considerably. Green sawdust and shavings, although in limited supply, may cost \$10 to \$15 per tonne delivered straight to the hopper with no intermediate storage. Whole tree chips, on the other hand, might cost \$30 to \$40 per green tonne delivered if

intermediate storage is involved. Based on a typical situation in which 200 litres of oil are displaced per green tonne of wood chips burned and an oil price of 33 ¢/litre, fuel savings of 40 to 80 percent are attainable.

3. Capital Investment

Approximate capital costs for typical installations of various capacities are outlined in the following table. It should be stressed that these estimates should not replace detailed cost estimates based on the operating parameters and characteristics unique to each potential site.

Capital Cost of Roundwood and

Wood Chip Fuelled Systems*

Current Oil Consumption (Litres)

<u>Fuel Type</u>	<u>50,000</u>	<u>100,000</u>	<u>400,000</u>	<u>2,400,000</u>
Roundwood	\$25,000	\$ 60,000	N/A	N/A
WoodChips	\$35,000	\$180,000	\$400,000	\$1,200,000

N/A: Not applicable -- see Part 3 for discussion of the suitability of roundwood and wood chip systems for the displacement of varying quantities of oil.

Assumption * Based on displacement of 80% of current oil consumption and no government assistance.

4. Payback

After reducing the potential fuel savings from burning wood fuel by the amount of additional operating costs (such as labour for loading and cleaning out ash) the simple payback can be

calculated. Examples of these paybacks (pre-tax) are as follows:

<u>System</u>	<u>Before Grant Investment</u>	<u>Litres of Oil Displaced</u>	<u>Fuel Cost</u>	<u>After Grant Pre-tax Payback</u>
Roundwood	\$25,000	35,000	\$60/cord	2.1 years
Roundwood	\$60,000	50,000	\$60/cord	5.2 years
Wood Chip	\$110,000	120,000	\$25/tonne	9.0 years
Wood Chip	\$160,000	200,000	\$30/tonne	5.8 years
Wood Chip	\$400,000	560,000	\$35/tonne	5.3 years

As the figures above show, three main variables have the greatest influence in determining how attractive a possible conversion project to wood fuel will be:

- i) The volume of wood fuel to be used.
- ii) The cost of the fuel in a form ready to use.
- iii) The capital investment required (net of grants).

It should be noted that EM&R's AEDP program can provide assistance that may reduce payback to 3 years. Details are included in Part 6.

Experience to date suggests that the highest returns on investment, especially for wood chip systems, come from sizing the equipment to provide the base, rather than the peak, load requirements. In general, the greater the number of days in which the equipment operates at full output, the greater the combustion efficiency and, ultimately, the higher the return per dollar of investment. Typically, the economically optimal size for wood chip systems results in the substitution of 65-75% of current oil consumption. In retrofit installations the existing

system can be used to supply peaking capacity and be used during summer periods.

Part 3: Woodchips or Roundwood?

Most people are familiar with wood stoves and furnaces that use roundwood fuel. There are suppliers of both boilers and furnaces which make units capable of a significant heating capacity. In fact, an Island company, ECIL Ltd., of Montague, has built two boilers for tobacco farmers that use roundwood fuel. These boilers have an output capacity of 3 MM BTU/hr (880 KW). The fuel is loaded as required using manual labour or tractor mounted front end loaders.

Wood chip combustion units normally use a screw auger that feeds the fire depending on the heat load that is required. A further description of these various combustion systems is provided in Part 5 of this guide.

The advantages and disadvantages of a roundwood fed system are given in Table 3.1.

Table 3.1

Advantages/Disadvantages of Roundwood

<u>Advantages</u>	<u>Disadvantages</u>
Cheaper Fuel than Woodchips	Fuelling is labour intensive
Reliable	Requires greater storage area for fuel, but requirements not so demanding
Less expensive	Nighttime Refueling may be required
combustion Equipment	

It is important to note that the relative advantages of the different forms of wood fuel supply change depending on the size

of the heating system being considered. For example, a wood chip stoker system of 0.75 MM BTU/hr (220 KW) capacity is more expensive on a \$/BTU basis than a roundwood unit having a capacity of 4 MM BTU/hr (1.2 MW). This is because the costs of items such as controls, fans, and augers do not decrease linearly with size.

There is no doubt that if no value is attributed to the maintenance and fuelling labour then the roundwood system is the preferable route. The increased cost of the wood chip combustion system is due to equipment design features that try to offer the same reliability and convenience as oil fired equipment. In practice this means that institutions and businesses that have no staff or equipment capable of loading large volumes of roundwood are better served by the more automated systems. Businesses in rural areas such as greenhouse operations or tobacco farms, are more suited to using industrial sized roundwood units. Recent experience, however, suggests that the decision is based on the individual preference at each site to take the time required to fuel the system or to realize the cost of having it done automatically.

It is worthwhile, at this stage, to outline the maintenance required for a small roundwood unit used to burn about 60 cords of fuel annually. About 100 hours/year are spent loading the boiler while the boiler and chimney are cleaned once a month during the heating season taking 50 hours total. Moving, blocking and storing roundwood takes another 130 hours. Thus, it can be observed that unless a site requires high output

capacity for a short period of time, such as a tobacco farm, and the output capacity is of a modest amount, 0.5 MM BTU/hr (145 KW) or less, then the labour requirement for roundwood systems becomes very significant.

4.0 Have We Got Enough Wood

4.1 Wood Supply - Have We Got Enough?

Any business seriously considering converting to wood fuel will want to secure an adequate wood supply. Unfortunately, as soon as one begins to talk to contractors in the wood industry, one is likely to hear about a shortage of wood. Let us, therefore, examine whether there is enough wood fuel on Prince Edward Island to sustain the expected growth in demand. The following analysis is directed towards businesspeople expecting to buy their wood from the commercial market. Persons with their own woodlots may already have a secure supply.

(i) Conventional Forest Products

The most readily available source of wood fuel is in the form of residue from forest products. Present harvest levels on Prince Edward Island are approximately:

	<u>Green Tonnes</u>	<u>Cords</u>
Sawlogs	75,000	42,000
Fuelwood	190,000	100,000
Pulpwood and other products	<u>50,000</u>	<u>28,000</u>
Total	315,000 =====	170,000 =====

Sources: Forest Resource Development Agreement, IEA 1984, Resource Ventures Inc., 1983.

Sawlogs should not be used for fuel; however, many sawlog operators leave significant amounts of low grade wood and slash in the cutover areas which could be available as low cost biomass fuel.

Most fuelwood is hardwood which is available at relatively high cost. Typical costs are \$34-\$42/tonne (\$65-80/cord) delivered in 2.5m (8 ft.) lengths. Hardwood fuelwood is in high demand by the residential sector and harvest levels may be at or beyond the sustainable level. A secure fuel supply can therefore be difficult to obtain over the long term.

Low grade hardwood and low grade pulpwood is a wood product with good fuel potential. Pulpwood is all presently exported and can be obtained at approximately \$28/tonne (\$50/cord) delivered. The pulpwood industry has a supply infrastructure and established market and could provide the most secure source of supply.

Wood wastes from sawmills provide a final potential source of supply. Estimated wastes produced and available from the larger Island sawmills are approximately:

	Green Tonnes	
	<u>Production</u>	<u>Surplus</u>
Slabs	20,000	300
Sawdust	8,000	2,600
Shavings	<u>3,200</u>	<u>830</u>
Total	31,200 =====	3,730 =====

Source: Spatial Planning 1982, IEA 1984.

Most slabs are presently sold for residential firewood. Sawdust is sold for fuel and for agricultural uses. Shavings are sold for agricultural uses. Much of the surplus must be disposed of by the sawmill owner and can be obtained at low cost. Sawmill residue production levels fluctuate with the economy.

(ii) Available Biomass

Prince Edward Island has approximately 250,000 ha (610,000 acres) of stocked forest land. If each hectare is assumed to grow 200 green tonnes of biomass fuel (43 cords/acre) over a 50 year period then 1,000,000 green tonnes (520,000 cords) should be available for harvest each year. With current harvest levels at approximately 315,000 green tonnes, approximately 685,000 green tonnes of fuel are available for harvest each year without overcutting the forest. Even if only 55% of the forest resource on Prince Edward Island is available for harvesting, at least 235,000 additional tonnes of fibre could be harvested for fuel on a sustainable basis. Most of this surplus is in poplar and low grade softwood stands which have little other market potential.

A more detailed analysis of the sustainable harvest is presented in IEA (1984) and summarized in Table 4.1. The analysis is based on:

- i) 1982 Provincial Forest Inventory
- ii) 55% of provincial forest land being available for management
- iii) an average forest rotation (age at harvest) of 50 years
- iv) 23-33% of harvestable biomass being left in cutovers with conventional harvesting methods (this is assumed to be waste).

Figure 4.1 outlines the regional boundaries used which correspond functionally with each major population area. The map also illustrates the approximate concentrations of forest land on Prince Edward Island.

Table 4.1
Estimated Annual Forest Biomass
Available for Fuel on P.E.I. by Region

	GREEN TONNES
<u>Souris/Montague Area</u>	
Annual Growth	309,000
Present Harvest	136,000
Available Fuel	<u>173,000</u>
<u>Charlottetown Area</u>	
Annual Growth	185,000
Present Harvest	138,000
Available Fuel	<u>47,000</u>
<u>Summerside Area</u>	
Annual Growth	121,000
Present Harvest	102,000
Available Fuel	<u>19,000</u>
<u>O'Leary/Tignish Area</u>	
Annual Growth	117,000
Present Harvest	70,000
Available Fuel	<u>47,000</u>
<u>Total Prince Edward Island</u>	
Annual Growth	733,000
Present Harvest	446,000
Available Fuel	<u>287,000</u>

Note: Present harvest includes estimated residual waste.

Figure 4.1
Forest Biomass Densities on Prince Edward Island

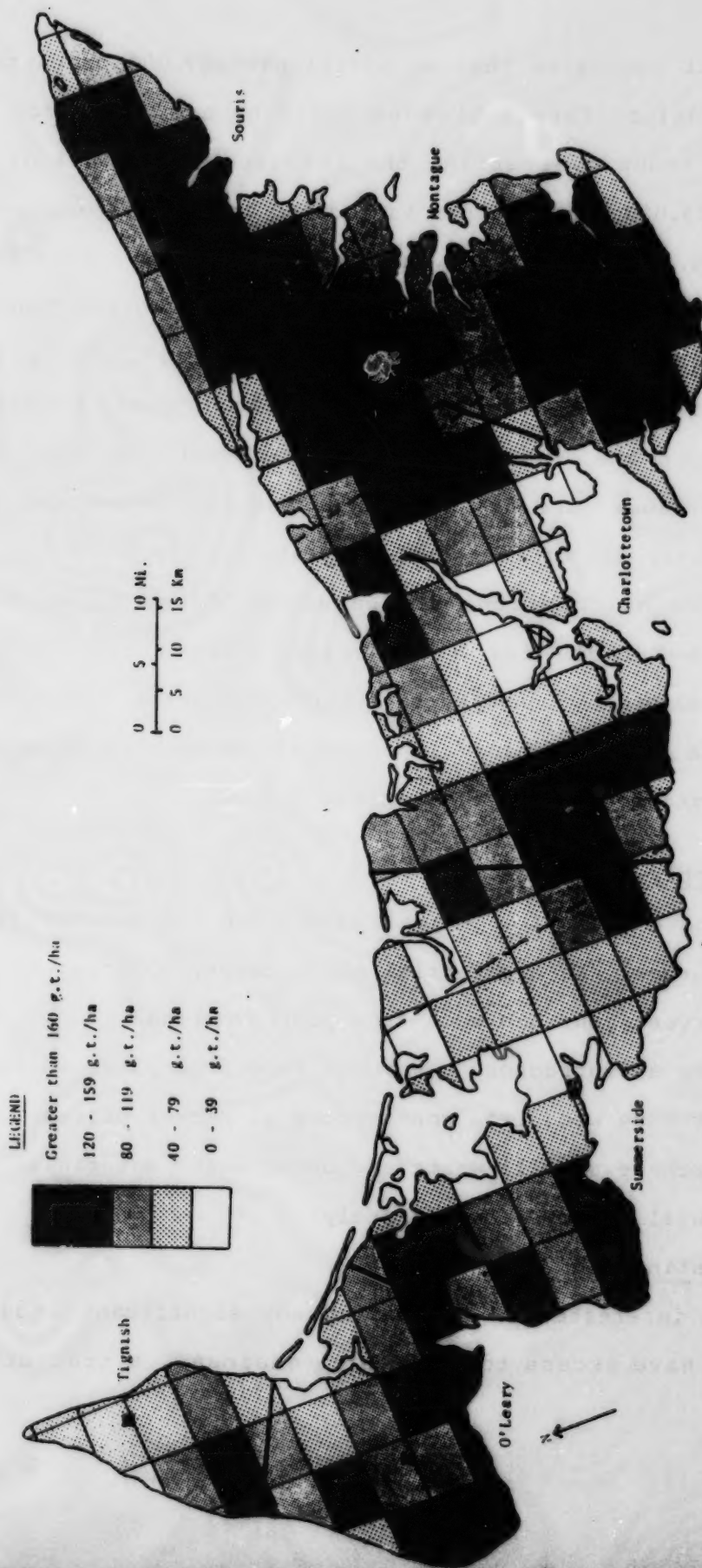


Table 4.1 indicates that an additional 287,000 green tonnes (150,000 cords) of forest biomass could be available for fuel each year without overcutting the resource. Over 60% of this surplus or 173,000 green tonnes is located in the eastern quarter of the Island. The remaining surplus is divided into 47,000 green tonnes in the Charlottetown Area, 19,000 green tonnes in the Summerside area and 47,000 green tonnes in the western quarter of the Island. An additional 117,000 green tonnes may be available in the form of waste from conventional operations. The waste residues are distributed across the Island and would be approximately 25% of the total harvest.

The above calculations are based on 55% of P.E.I. forest land being available for harvest and present average stand volumes of 260 green tonnes/hectare (56 cords/acre). Improvement in both these values through improved management could increase available biomass substantially in the future.

4.2 Wood Supply-How to Get It

The wood supply for a heat plant can be secured from a number of sources. As a potential plant owner, you can:

1. Harvest your own wood from your own land;
2. Hire a contractor to harvest wood from your own land;
3. Purchase wood from contractors at market prices;
4. Purchase sawmill waste and other waste materials.

Each method will be covered separately.

4.2.1 Harvesting Your Own Wood

Persons interested in harvesting any significant amount of wood should have access to at least a chainsaw, a tractor with

winch and a pickup truck. For volumes greater than 40 tonnes (21 cords), two or more chainsaws, a skidder and a large truck are recommended.

Table 4.2 outlines typical values for estimating the time and costs involved in harvesting your own wood supply in roundwood form. The analysis assumes a clear cutting operation with semiskilled workers, and 48-66 tonnes (25-35 cords) of material per hectare.

Table 4.2

Typical Times and Costs Involved in Harvesting Wood for Chips

	<u>Tonnes</u>	<u>Cords</u>
Labour Hours per Unit:	hr/tonne	hr/cord
Cutting and Piling	1	1.9
Forwarding with Tractor	0.5	1.0
Loading (Manually)	0.2	0.4
Delivery (1 tonne load @15 km)	1	1.9
Unloading (Manually)	<u>0.1 hrs.</u>	<u>0.2 hrs.</u>
Total	<u>2.8 hrs.</u> =====	<u>5.4 hrs.</u> =====
Direct Cost Per Unit:		
Fuel and Oil for Saws	0.40	0.75
Tractor Fuel	0.75	1.45
Delivery Vehicle Fuel	2.00	3.80
Maintenance	<u>1.00</u>	<u>1.90</u>
Total	<u>\$4.15</u> =====	<u>\$7.90</u> =====

Sources: Savage and O'Hara, Island Energy Associates 1981, Peters 1982, IEA 1984.

As a rough guideline, the owner of a business that requires 50 tonnes of fuel per year can expect to spend 140 hours and \$207.50 in direct expenses producing his own wood supply. The costs of purchasing or renting the required equipment would be extra.

The additional cost and time required for chipping are analysed in Section 4.2.2.

4.2.2 Hiring a Contractor

Contractors can be hired for all phases of the fuel supply operation. The quoted costs are typical under normal conditions and vary significantly with the harvest site, the contractor and the fuel type. The general tasks performed by contractors include:

1. Harvesting
2. Forwarding
3. Processing
4. Trucking

Purchasing processed fuel is covered in Section 4.2.3.

(i) Harvesting and Forwarding

Cutting and forwarding can be done as a commercial thinning operation to improve a forest stand or as a final harvest to liquidate the stand. Contractors are generally paid on an area and/or volume basis.

For pulpwood thinning operations, cutting and piling production ranges from 0.1 to 0.3 hectares (0.3 - 0.7 acres) per man day. Typical harvesting production costs would be:

	<u>Tonnes</u>	<u>Cords</u>
Productivity Per Man Day	4-8	2.1 - 4.2
Cost Per Unit	\$7-18	17.10 - 34.20

The cost of moving the wood to roadside depends on wood volume, distance, condition of trails and equipment used. A tractor, winch and operator with an average distance of 100m can be expected to forward 16-20 tonnes per day. A forwarder and operator can be expected to move 40 to 60 tonnes (20-30 cords) per day from a thinning operation. Typical forwarding production costs would be:

	<u>Tonnes</u>	<u>Cords</u>
Tractor - Daily Production	14-18	7.4 - 9.5
- Cost Per Unit	\$9-12	\$17.10 - 22.80
Forwarder - Daily Production	40-60	21.10 - 31.60
- Cost Per Unit	\$ 5-7.50	\$ 8.50 - 14.25

A skidder would be slightly less productive than a forwarder. The Canadian Forestry Service pays a silvicultural incentive of up to \$580.00/hectare (\$240/acre) for commercial thinning operations.

A typical clearcutting operation is 50% to 100% more productive than a thinning operation. Cutting and piling rates of 8-18 tonnes per man day and forwarding rates of 60-70 tonnes can be expected. Typical production and costs would be:

	<u>Tonnes</u>	<u>Cords</u>
Harvesting - Production Per Man Day	8-18	4.2 - 9.5
- Cost Per Unit	\$4-\$9	\$7.60 - \$17.10
Forwarding - Production Per Day	60-80	31.6 - 42.1
- Cost Per Unit	\$4.00-\$5.30	\$10.10

Production may be increased and cost reduced significantly by mechanizing the felling operation.

A typical cost structure for producing wood at roadside would be:

	Thinning		Clearcut	
	<u>Per Tonne</u>	<u>Per Cord</u>	<u>Per Tonne</u>	<u>Per Cord</u>
Cutting and Piling	\$13.50	\$26.65	\$6.50	\$12.35
Forwarding	10.50	19.95	4.65	8.85
Stumpage	2.00	3.80	2.00	3.80
Incentive	<u>(12.00)</u>	<u>(22.80)</u>	<u>-</u>	<u>-</u>
Total Cost	\$14.00 =====	\$26.60 =====	\$13.25 =====	\$25.00 =====

Where wood is to be cut from land under separate ownership, stumpage rates of \$2 per tonne (\$3.80/cord) can be expected. If wood is to be chipped at roadside, whole tree forwarding may increase productivity and reduce costs.

(ii) Processing

The requirements for processing depend primarily on the volume and the type of fuel used. For roundwood, processing would usually be limited to cutting the wood to shorter lengths. This is best arranged with the contractor when the wood is cut or purchased. Costs depend on the actual requirements and may be as high as \$15/tonne (\$28.50/cord). A list of companies who supply wood chips or rent chipping equipment is included in the Appendix.

Present rental prices range from \$75/hr for a large mechanically fed chipper to \$500/week for a small manually fed one. Typical chipping costs would be:

	<u>Small Chipper</u>	<u>Large Chipper</u>
Production	3 1/2 tonne/hr.	9 tonne/hr.
Costs: Chipper	\$12/hr.	\$75/hr.
Labour (2 men)	15	included
Fuel	4	included
Maintenance & Transport	<u>\$5</u>	<u>5</u>
Total	\$36/hr. =====	\$80/hr. =====
Cost Per Unit	\$10.30/tonne	\$8.90/tonne

Costs vary significantly with chipper, feed stock and operating conditions. The cost of transporting the chipper must be added.

(iii) Trucking

The cost of trucking varies with fuel type, haul distance and volume. The following general guidelines may be used for contract trucking based on a 25 km (15 mile) haul:

<u>Truck</u>	<u>Fuel</u>	<u>Cost/Hr.</u>	<u>Cost/Tonne</u>
12m Pulp Truck ¹ (40 ft)	38 tonnes Pulp Wood (20 cords)	\$50	\$3.75/tonne (\$7.15/cord)
5m Log Truck ¹ (18 ft.)	17 Tonnes Pulp Wood (9 cords)	\$40	\$5.55/tonne (\$10.55/cord)
3m Dump Truck ² (12 ft.)	6 Tonnes Chips	\$28	\$9.30/tonne
7m Dump Trailer ² (22 ft.)	11 Tonnes Chips	\$45	\$8.20/tonne
Container Truck (40 yd. container)	9 Tonnes Chips	\$60/load plus \$1/mile	\$8.30/tonne

- ¹ 2 1/2 hours for loading, transporting and unloading
² 2 hours for loading, transporting and unloading

Significant discounts may be arranged for large contracts, flexible delivery and/or favourable conditions.

4.2.3 Wood Purchase

Roundwood can be purchased from existing fuelwood and pulpwood suppliers at market prices. Hardwood can be purchased from any of a number of firewood suppliers on the Island. A complete list can be obtained from the Provincial Department of Energy and Forestry. Typical 1984 market prices for 2.5 m (8 ft) lengths were:

	<u>Tonne</u>	<u>Cord</u>
Cost Roadside	\$21-29	\$40-55
Cost Delivered	\$29-\$37	\$55-70

The delivery cost varies with haul distance. Substantial discounts may be obtained by ordering early, accepting low grade wood and contracting for large volumes. The wood can be purchased in short lengths for additional cost. Most contractors will deliver.

Pulpwood can be purchased in 2.5 m (8 ft) lengths directly from pulpwood dealers. Typical 1984 market prices were:

	<u>Tonne</u>	<u>Cord</u>
Cost Roadside	\$16-20	\$30-38
Cost Delivered	\$24-29	\$45-55

The actual delivery cost varies with haul distance. Significant discounts may be obtained by accepting low grade wood or watching the market for periods of surplus when prices are low.

Wood can presently be purchased in chip form from a few Island contractors. In 1984, four companies were set up to provide wood chip fuel. Quoted prices range from \$30 to \$40/tonne delivered and vary with volume and haul distance.

4.2.4 Purchase of Sawmill Wastes

A number of sawmills on the Island have large amounts of waste available for fuel in the form of slabs, sawdust and shavings.

During the last few years, slabs have developed a large market as fuelwood so that most sawmill operators presently sell all of their slabs. Typical 1984 market prices were:

	<u>Tonne</u>	<u>Cord</u>
Cost at Mill	\$0-14	\$0-27
Cost Delivered	\$9-25	\$17-48

Some sawmill owners may be willing to reduce their prices to supply one or more large buyers on a contract basis. Most sawmills will arrange delivery.

Sawmills either sell their sawdust and shavings or dispose of them as landfill or waste. All regions have mills where sawdust and shavings can be purchased. Sawdust is the more desirable fuel because of its high bulk density. Sawdust can be purchased for \$0 to \$10 per tonne at the mill and \$13 to \$22 per tonne delivered. Most sawmills will arrange delivery.

Shavings are less desirable as fuel because they have low bulk density. One exception is the dry shavings supplied in bale form by Schurman's Mill in Summerside. These are used in a special burner designed to burn dry shavings. For auger fed equipment shavings should be mixed with green sawdust if they are to be used as fuel. The mix should be obtainable at prices comparable to sawdust.

4.3 Wood Supply-Contracting for Wood Fuel

The important considerations in contracting for wood fuel are fuel specification, delivery and price. Specifications for roundwood/slabs and chips/sawdust will be discussed separately.

4.3.1 Roundwood and Slabs

Roundwood and slabs are readily available and have straightforward specifications. In the present market, arrangements are commonly made verbally.

(i) Fuel Specification

The roundwood contract should specify species, moisture content, size and quality. Conventional hardwood has high heat value per unit volume leading to a high demand from the residential market and a high price. Softwood and poplar is readily available in pulpwood form and would usually be more economical for large-scale applications.

Green wood has a moisture content of 45-55%. Wood which is seasoned for six months to one year should have a moisture content of 30-35% and will therefore burn more easily and generate more heat per unit. Seasoned wood can be purchased at a premium ranging from \$0-\$7 per tonne (\$0-\$14/cord).

Suitable fuel size is determined by the firebox size of the combustion unit and the chipper if the wood is to be chipped. Contracts should specify log length. Typical market lengths are 0.4m (16"), 0.6m (24"), 1.3m (4 ft.) and 2.5m (8ft). For chipping, the maximum diameter that the chipper can process must be considered. Small chippers are limited to log diameters of

15-20 cm. (6-8 inches). Large chippers can process logs up to 40 cm (16 inches) in diameter.

The contract should also specify the acceptable fuel quality, such as the percentage of rotten logs. Market fuelwood and pulpwood will be of high quality and should have little or no rot. Low grade fuel and culls may be unsuitable for normal markets and may be secured at substantial discounts.

(ii) Delivery and Price

The contract should also specify delivery and price. Roundwood is easily stored so delivery specifications are generally limited to the week or month of delivery. Roundwood is usually purchased in one or more larger shipments. Prices are presently quoted by the cord (approx. 1.9 tonnes). The cord measure is 128 cubic feet (3.5 cubic metres) which ranges from 70-90 cubic feet (1.6 -2 tonnes) of solid wood. Average cord measures are approximately 85 cubic feet (1.9 tonnes) for roundwood and 75 cubic feet (1.7 tonnes) for slabs. Contracting wood by the tonne can eliminate the above inconsistencies if scales are available and the moisture content of the wood is known.

4.3.2 Chips and Sawdust

Chips and sawdust are available on the present market in various forms. Typical specifications for wood chips will be discussed and can generally be applied to sawdust. A sample contract specifications is included in Figure 4.2.

(i) Fuel Specifications

The chip contract should specify the fuel size, moisture content and acceptable bark, sawdust and dirt content. Fuel size limits are generally determined based on the combustion unit. Typical specifications will range from 0.6 x 1.3 x 2.5 cm (1/4 x 1/2 x 1 inch) to 1.2 x 2.5 x 5 cm (1/2 x 1 x 2 inches). Larger particles may cause problems with some fuel handling systems. The maximum allowable moisture content will be determined by the combustion unit and economics. Drier fuel generates more heat per unit. An example of the value of oil displaced per green tonne of wood for various moisture contents is:

<u>MC</u>	<u>Value of Oil Displaced¹</u>	<u>Index</u>
60%	\$33.70	64
55	39.96	76
50	46.22	88
45	52.48	100
40	58.74	112
35	65.00	124
30	71.27	136

¹ Based on wood burner efficiency of 65%, oil burner efficiency of 80%, and oil at \$0.30 / Litre.

The table clearly demonstrates the increased value of dry chips on a green basis. Further discussion is included under pricing. However, combustion systems that can use green wood chips often have a minimum allowable moisture content since the high temperatures generated by dry wood fuel can cause damage to burner grates. The acceptable levels of bark and fine materials will also be determined by the combustion unit. The contract should specify a maximum acceptable level. Dirt in the fuel will cause ash and slag accumulations in the combustion unit resulting

in maintenance problems. The contract should specify a maximum acceptable level.

(ii) Delivery.

Where adequate storage cover is available at the combustion site, delivery can be arranged in one or more large shipments during the heating season. For large sites with limited storage, periodic shipments should be arranged. In these situations the contract should specify approximate monthly demand, storage capacities and expected delivery schedules.

(iii) Price.

Price should be based on weight, moisture content and chip quality. A typical price schedule based on moisture content is given in the sample contract specification. Where oversize material, undersize material or dirt levels are beyond the specifications, the contract usually provides for rejection of, or partial payment for the load. These conditions must be acceptable to the contractor if a reliable fuel supply is required.

Figure 4.2

Sample Specifications for Wood Chip Fuel

WOOD CHIP SPECIFICATION FOR ABC CO.

1. General Requirements:

An estimated 600 green tonnes of wood chip fuel are required for ABC Co. in Anytown, P.E.I for the period from September 1, 198X to April 30, 198X.

2. Fuel Characteristics:

- (i) Composition: The fuel shall be in wood chip form. The fuel shall be no more than 2% ash and 1% dirt by weight of dry fuel. The fuel shall not have any metal, glass or stones or excessive levels of snow and ice.
- (ii) Fuel Size: The maximum chip size will be 5.1x5.1x1.3 cm (2"x2"x1/2). The fuel shall not contain more than 1/2% oversized material by weight. The fuel shall not contain more than 10% by weight of materials capable of passing a 0.64 cm (1/4") screen.
- (iii) Moisture Content: No fuel over 55% (wet/basis) moisture content will be accepted.

3. Estimated Requirements:

Approximately 600 tonnes of fuel at 45% (wet basis) moisture content are required for the contract. Estimated monthly requirements are:

<u>Tonnes @ 45% M.C.</u>	
September	50
October	60
November	70
December	90
January	100
February	100
March	80.
April	50
	600
	===

4. Delivery Requirements:

Delivery will be required in correspondence with plant requirements. On site storage is limited to 15 tonnes or 5-6 days supply at maximum output. The fuel bin will require a conventional dump truck or similar truck for unloading. Delivery must be made during regular business hours.

5. Pricing

The following pricing schedule will be applied:

<u>MC% (wet basis)</u>	<u>Price/Green Tonne</u>
45.1 - 50.0 %	\$26.40
40.1 - 45.0	30.00
35.1 - 40.0	33.60
30.1 - 35.0	37.20
< 30.0	40.80

Load weight will be established and checked periodically.
Moisture content will be measured by the Purchaser using
conventional methods.

5.0 Combustion Equipment Fuel Storage & Handling

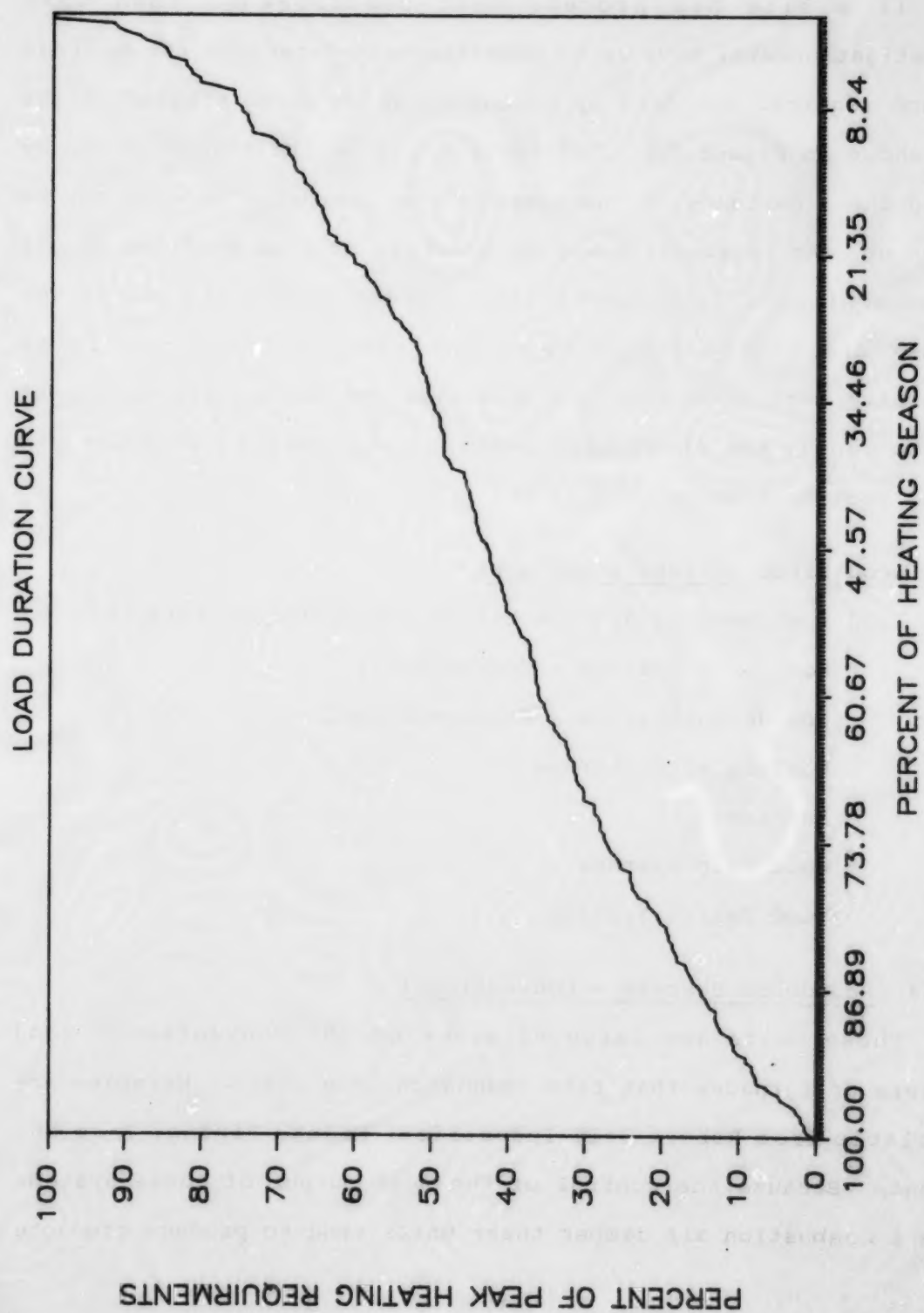
This section reviews the question of the appropriate size of the wood fuelled heating system and the merits and limitations of available equipment.

5.1 Sizing of Equipment - Space Heating

Since wood fired equipment is 2-4 times the cost of oil fired equipment it is important that the equipment is used as close to capacity as possible. The ratio of actual heat required compared to the maximum output possible is known as the load factor. In space heating applications with oil heating equipment an annual load factor of 30% can be expected. It can be shown that a wood fuelled system can have a significantly higher load factor of 50-70% if the peak heating requirements are supplied with oil or propane fuel. Figure 5.1 shows a typical heating load profile for P.E.I. Note that 50% of the annual heating load can be satisfied with a heating system having only 35% of the capacity needed to meet the peak heating load.

Therefore in retrofit space heating applications a useful sizing criteria for a wood heating installation would be 50-65% of the existing capacity that is known to be adequate to meet design loads. Since in almost all cases a backup fossil fuelled heating system will be available, the existing system should be used to provide the peak heating requirements while the wood fuelled system provides the base load. In addition, wood fired systems have their highest efficiency when operated at full load.

Figure 5-1



5.2 Size of Equipment - Process Loads

If a site has process heat requirements then some investigation will have to be undertaken to determine the maximum demand required and draw up a load duration curve similar to the one shown in Figure 5.1. Information may be limited. However, by using the experience of the operator, an approximate curve may be drawn up. An inexpensive way of determining load profiles on oil fired equipment is by installing a timer on the oil gun of the boiler and taking daily, weekly or monthly readings. It is generally more economical to undersize the wood fired equipment and to supply the short term peaking requirements with the oil fired back up system.

5.3 Wood Fired Boilers & Furnaces

Wood fuel heating systems can be classified as follows:

- Roundwood Systems - Conventional

- Roundwood Systems - Unconventional

- Boilers with Storage

- Furnaces

- Wood Chip Systems

- Wood Pellet Systems

5.3.1 Roundwood Systems - Conventional

These units are large versions of the conventional wood boilers or furnaces that burn roundwood on a grate. Examples are available from Robert Bell Industries, Franks Piping, Tarm and Passat. Because the control of the heat output of these systems uses a combustion air damper these units tend to produce creosote

and require more maintenance than wood chip fuelled systems. Boiler tubes and heat exchanger surfaces have to be cleaned regularly in order to maintain good thermal efficiency.

Due to the large mass of fuel loaded into the firebox the control of output from these designs may be less precise than other systems. Some designs use small fans to blow combustion air into the fuel chamber which makes them more responsive than natural draft units.

A most important design feature of a roundwood system is the firebox capacity. Since loading the unit is carried out manually, the frequency of loading will be proportional to the firebox size. Table 5.1 gives the required number of loading times required to keep a 500,000 BTU/hr roundwood system operating at various output levels.

Table 5.1

Fuel Loading needed to keep a 0.5 mm BTU/hr roundwood system at various output levels.

<u>Output (%)</u>	<u>Loadings/24 hr.</u>
100	8
50	5
25	4

However, despite the higher level of effort required to operate roundwood systems, the investment cost of these systems can be much less than more automated ones. For applications that require high outputs for short periods of time, such as tobacco farms or greenhouses, the low investment cost may outweigh the

maintenance and loading requirements. These systems have the additional advantage of simplicity and have proved to be reliable. However, these systems should only be installed in sites that require less than 100 cords/yr in fuel unless materials handling equipment such as front end loaders are available.

5.3.2 Roundwood Systems - Unconventional

In the last five years there have been a number of designs that have attempted to reduce the level of maintenance required for industrial roundwood systems.

5.3.3 Heat Storage

Including a volume of heated water in a boiler will enable thermal energy to be stored in the system thus enabling the fuelling time to be at the operator's convenience. The fact that the wood boiler is fired at high output to charge up the storage tank also greatly reduces the build up of creosote on the boiler tubes. However, the incremental costs to be considered include the cost of the storage tank, associated piping and a larger capacity boiler. The latter is required in order that the storage may be charged over a reasonable time when there is also an existing heating demand that is simultaneously drawing down the heat stored in the storage system.

5.3.4 Storage Tank Design

Tanks containing water at atmospheric pressure are cheaper than steel tanks that are required to withstand the operating pressure of conventional heating systems. However, experience has shown that water in atmospheric tanks can dissolve oxygen

from the air and this oxygen combined with the temperature cycles experienced by the tank can lead to accelerated corrosion in this type of tank.

The choice of suitable storage tanks should be checked with a company experienced with installing such heat storage systems. Two Canadian companies which sell boilers designed for use with heat storage are Kerr Controls and Robert Bell Industries. A local company with this type of system is the Wood Shed Heating Systems.

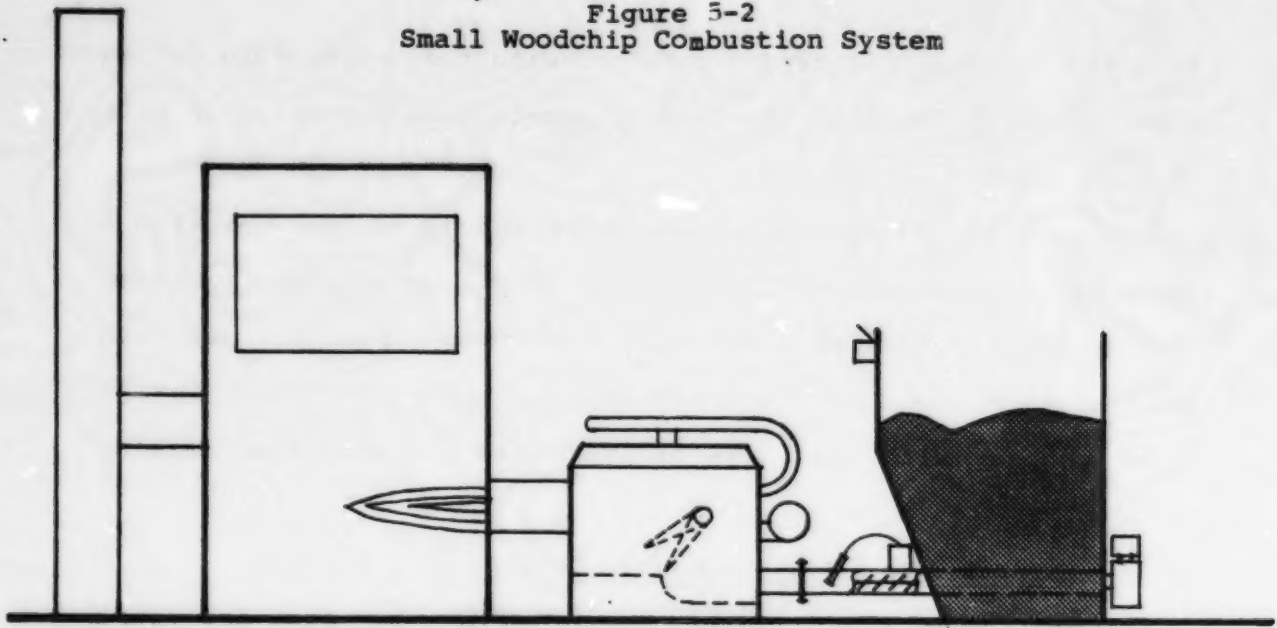
5.3.5 Firebox Above Heat Exchanger Designs

A new design that has been developed over the last few years in the United States uses a large firebox that is located above the heat exchanger. Wood gases given off by the burning wood charge are burnt in a refractory lined tunnel before passing through boiler heat exchange tubes in the base of the unit. When heat is not required the fuel mass smolders in the insulated refractory firebox. It is claimed that off cycles as long as 8 hours may be achieved. Examples of this design are fabricated by Eshland and Essex.

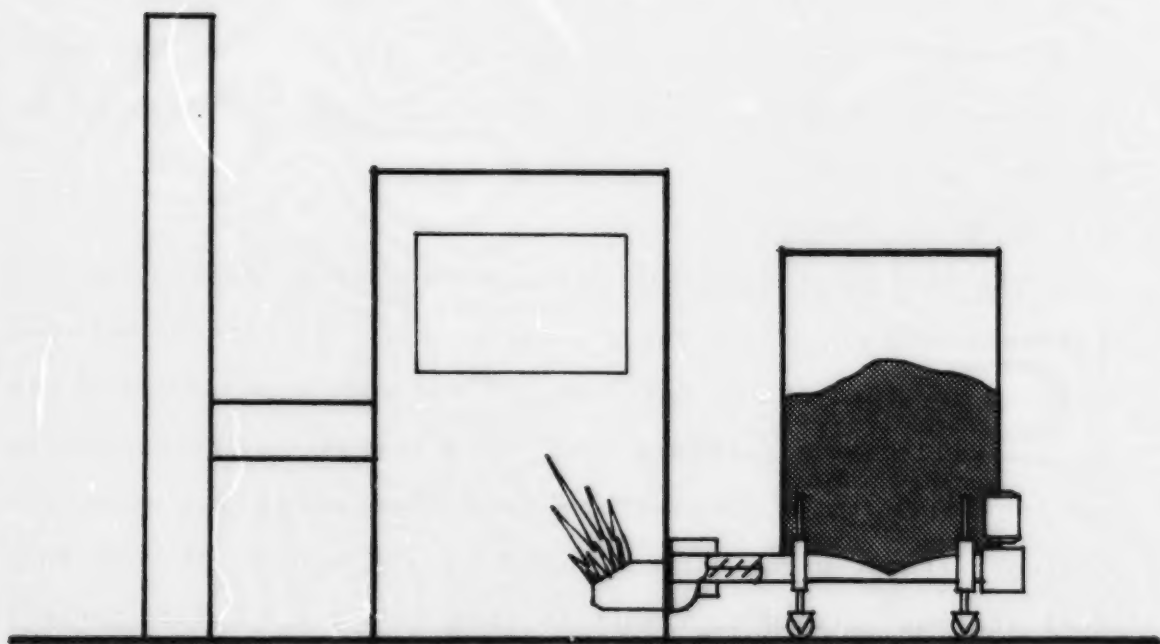
5.4 Woodchip Systems

The design of woodchip combustion systems depends on the moisture content of the fuel. In general, the division between wet and dry fuel can be taken as 30% and woodchip fuel from the forest will have a moisture content of 45-50%. It is generally not possible to dry and store woodchips below 20% moisture content without using heat. In P.E.I., the sources of wood chip fuel are most likely to result in fuel having a moisture content greater than 30%.

Figure 5-2
Small Woodchip Combustion System



PreCombustion Stoker Design



Stoker Design

5.4.1 Preheater Design

A well proven design for small wood chip combustion systems is that shown in Figure 5.2. Wood chips are burnt in a combustion cell or chamber using a small fan to provide combustion air. The chamber is lined with refractory and insulated. The hot exhaust gases are then passed through a heat exchanger before being discharged up a stack. An advantage of this design is that a roundwood boiler or furnace can be used as the heat exchanger in small systems so that roundwood can be used in the unit if the wood chip supply is disrupted.

The control of these type of systems is achieved by having a low fire - high fire control. When the system is not calling for heat a small amount of wood chip fuel is fed into the preheater, enough to keep an ignition fire alight. The refractory firebrick that surrounds the burning fuel ensures that the wood gases are fully burnt and hence that there is a minimum formation of creosote. This type of precombustion design is available from small sizes of 200,000 BTU/hr (58 KW) up to systems in excess of 5 MM BTU/hr (150 boiler HP 1.5 MW). The installation at the Kings County Memorial Hospital in Montague uses this type of design and a schematic of the system is shown in Figure 5.3. A general schematic of the system is shown in Figure 5.3.1. This type of design has worked well with wood chip fuel up to 55% moisture content by weight. The disadvantage is that, because the design uses more materials, it is more expensive than the stokers described in 5.4.3.

Figure 5-3

KINGS COUNTY MEMORIAL HOSPITAL Wood Chip Fired Boiler

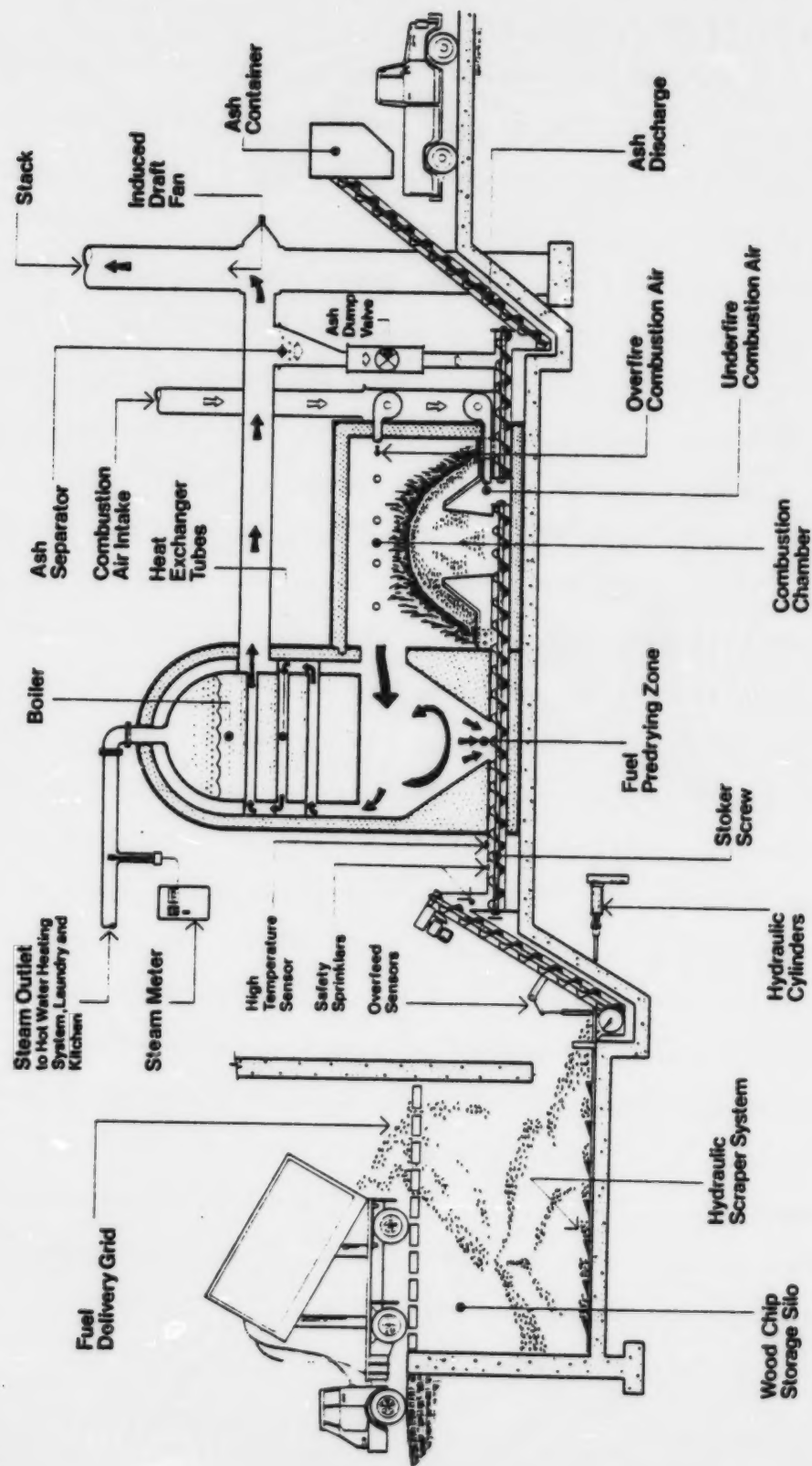
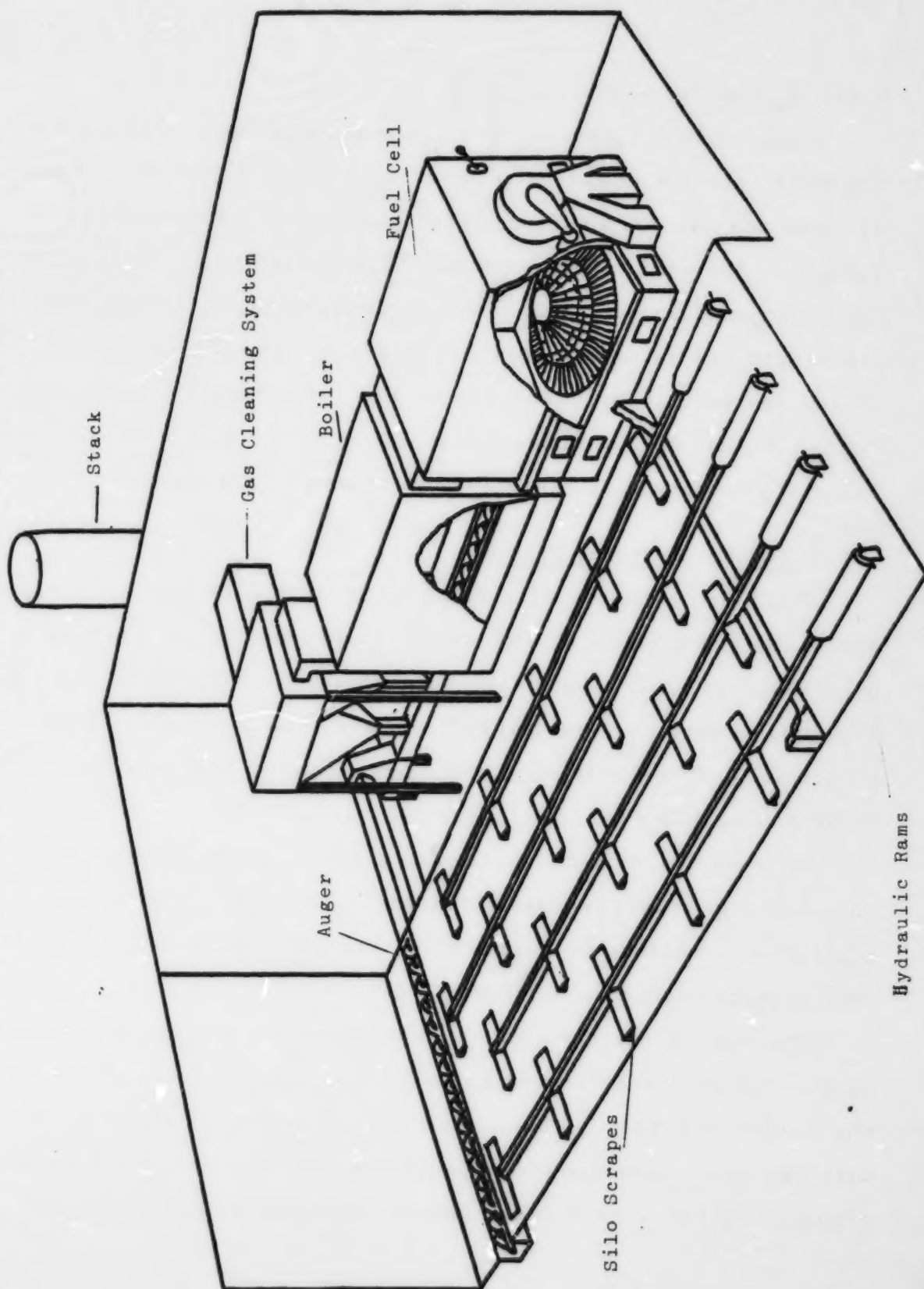


Figure 5.3.L
General Schematic of Underfed Stoker System with Silo & Scrapers



5.4.2 Preheaters - Gravity Fed

Some designs of preheaters use a gravity feed to introduce the fuel into the combustion chamber (Figures 5.4, 5.5). These systems use natural draft and the fuel feed is regulated by the demand on the unit. These systems have proved to be successful for using sawdust fuel and mixed sawdust/shavings. The systems are simple and reliable and work with a minimum of electricity. Thirty residential systems made by Precision Products have been operating in P.E.I. since 1981. Companies fabricating or importing this type of equipment are listed in the Appendix.

5.4.3 Underfeed Stoker Systems

There are a number of designs which introduce the wood chip fuel into the firebox of the boiler furnace directly without a precombustion cell. Originally these designs were used to burn dry wood wastes such as chipped edgings from the wood products industries. An example of a small system using this principle is shown in the lower part of Figure 5-2.

Because the system is simpler these designs are generally cheaper than the preheater designs. However, they tend to require more uniform wood fuel chip size and require average wood chip moisture contents no greater than 35-40%.

The reason for the increased sensitivity to fuel moisture content is that the firebed loses heat by radiation directly to the boiler surfaces. Thus, when the system is on standby, the fuel bed cools down and poor combustion occurs. Among the small sizes of stoker, the Vallsta design imported by BDR Machinery,

incorporates an electric coil that re-ignites the fuel each time the burner starts up from an off cycle. This is a promising development, since lower fuel consumption can be achieved at low firing rates.

5.5 What To Look For In A Supplier's Quotation

This section is included to assist small companies and individuals who wish to carry out their own feasibility analysis and outlines the information exchange between the user and the equipment supplier.

The equipment supplier needs to know the details of your application. This would including the following items:

5.5.1 Existing System

Existing Boiler (BHP)

Existing or Anticipated Fuel Use (litres)

Heat Transfer Fluid (Hot Water/Steam)

Operating Pressure (PSIG)

Description of Heat Load (If Process Heat, a short description of anticipated load savings)

Feed Water (City/Well/Reliability of Supply)

Electrical System Available (Phase, Voltage, Amps)

5.5.2 Proposed System

Boiler Capacity (BHP, MM BTU/hr)

Operating Pressure (PSIG)

Temperature

Planned Use (a short description of how the system is proposed to operate e.g. base load unit with existing system picking up the peak loads)

Storage Silo Dimensions and Required Capacity

Specify if Energy Efficient Electrical Motors to be used in the system

Site sketch (This would show the proposed relationship between the existing boiler system, the new wood fired boiler system and the storage silo)

5.5.3 Wood Fuel Specification

Principal Wood Fuel (Wood Chips, Sawdust, Roundwood)
Moisture Content Range (% M.C. wet basis) Size Specification

Other Wood Fuel Available (Sawdust, Shavings, Bark, Roundwood) Size and Moisture Content Specification

The more precise the information that can be given to an equipment supplier then the more reliable the cost information that can be obtained. In reviewing quotations the following items should be noted.

- a) Has the supplier given you the information requested?
- b) Does the quotation state that the materials handling equipment can handle the fuel specifications given?
- c) What percentage of other wood fuels (e.g. sawdust in a wood chip burner) can be used?
- d) What is the electrical load of the proposed system. Are efficient motors specified? If the unit is imported, does the electrical system conform to CSA standards?
- e) Is an stack included? Is it insulated?
- f) Is the system manual or semi-automatic ash removal? Have all tools for ash removal been included?
- g) Does the quotation include transportation cost to your site?
- h) In a larger system, what kind of start-up assistance will the manufacturer give? Is this an extra cost item?
- i) If the combustion cell is to have the refractory installed on site is it clear that all site costs are included in the quotation?
- j) If the equipment is to be installed by others at the site ensure that the degree of site fabrication, welding, etc.,

is clearly outlined and counted for in the quotation.

- k) What are the payment terms? Is a holdback allowed until the system is proven?

Many of the above points will not be mentioned in the quotation unless you ask for them specifically. However, note that the more restrictions that are placed on the equipment supplier the higher the supplier must make the price in order to realize the requirements. Experience has shown that most surprises are associated with extra costs incurred during the installation of the equipment.

Visiting sites in which the supplier has placed equipment recently or talking to people involved in using the equipment is a good way of checking on the reliability and reputation of a supplier.

Turnkey Systems

The larger equipment suppliers can offer a turnkey installation. In many ways this is desirable since the responsibility for equipment installation is taken by the equipment manufacturer who is experienced with wood fuel installations. With turnkey installations the client states the performance guarantees that are required; the supplier then quotes for the installed equipment. In practice, with small installations (less than 200 KW) this may be too expensive and a partial turnkey installation in which the installation of the system is carried out by others may turn out to be the most cost effective solution.

5.5.4 Stack Design

With roundwood fuel it is advisable to use a stack design that can withstand a flue fire. Incomplete combustion can create creosote build up in the chimney, particularly with round wood, and hence the chimney must be designed accordingly. For small wood chip fired systems, (0.2 - 0.5 MM BTU/hr, 60-150 KW) the chance of creosote build up is reduced. However since these units are connected to a boiler or furnace that can use roundwood, an approved chimney is still recommended.

Larger systems will use an induced draft fan to suck air through the combustion system when the wood chip fuel is being fed into the unit (high fire); natural convection takes place on low fire. The stack is an important part of the combustion system and should be sized by the equipment supplier. The stack should be double wall construction and insulated because the combustion of wet wood results in the stack having to pass a large volume of wet flue gases. If an uninsulated stack is used, then excessive condensation occurs during the winter and the condensed water has to be drained from the stack and disposed of. Streaking of the outside of the stack and corrosion the chimney may also occur. As well, natural convection may not take place during the stoker off-cycle due to cooling of the stack gases, leading to a loss of negative pressure in the combustion chamber and an increase in the possibilities of burnback in the feed screw. A stack should always have a drain port and also a clean out port at its base.

5.5.5 Dust Collection

The need for a flue gas cleanup system depends on the size of the system and its location. It is recommended that all systems over 1 MM BTU/hr (290 KW) located in an institutional or commercial site should include a particle cleanup system between the boiler discharge and the stack. A multicyclone is the most common system used on these small wood boilers with the dust and char particles being fed from the collection system into the ash discharge system.

5.5.6 Ash Discharge

Operation of a wood fired system will require the ash residue to be removed from the system at regular intervals. Removing and handling this residue is often overlooked in the planning of a new installation. Wood ash is very light and so, for systems greater than 1 MM BTU/hr, it is desirable to have an ash auger included in the design. This auger is a small screw that runs underneath the combustion cell and then outside to a container such as 45 gallon drum. Bottom ash is scraped through ports in the bottom of the combustion cell into this auger which also takes away the dust from the dust collector.

If manual ash collection is used then a shallow pan with a lid can be used to transport the ash outside. Because ash, when removed from the combustion unit often has burning material, it is essential that a non combustible container be used.

Wood ash is high in mineral content and can be sold to garden centres or farmers as fertilizer.

5.5.7 Control Systems

5.5.7.1 Safety Controls

A wood fired heating system has to include a number of controls for safety reasons. Some of these are also required on oil fired equipment.

5.5.7.2 Pressure Relief Valve

In a hot water boiler the system has to be fitted with an adequate pressure relief valve in the event that a power failure occurs when the system is operating at high fire. The loss of water circulation through the boiler may cause steam to be generated and the excess pressure has to be relieved by an adequately sized PRV.

5.5.7.3 Low Water Cut-Off

A control is required that prevents wood fuel feed if a low water condition is detected in the boiler.

5.5.7.4 Water Feed Control

A control is required such that make up water is available if a low water or low water pressure condition is detected. The power out case should also be considered. One method is to include a small accumulator in the water feed line to maintain system pressure if water pressure is maintained from electric pumps.

5.5.7.5 Fire Extinguisher System

In all stoker fed equipment there is a chance that when the unit is on standby and using dry fuel, fire will burn back through the stoker screw from the combustion chamber. Therefore, a water spray should be placed on the stoker tube. A temperature actuated valve opens the spray valve if a fire is detected in the tube. It is important that the operation of this water spray not depend on electrical power since it is during power failures that burn backs most commonly occur.

5.5.7.6 Operational Controls

How the new wood boiler is connected into the existing system depends on the site's specific situation. However, in simple retrofit situations there are two principal methods in which the systems can be connected. In the series hookup the supply from the wood boiler is passed through the backup oil system to the heating load. The aquastat on the backup boiler is set back such that the oil burner only starts when the wood boiler cannot maintain the supply temperature.

In a parallel connection the backup boiler remains cold until the wood boiler cannot meet the load whereupon a temperature controller starts the burner and associated circulation pump once the boiler reaches its operating temperature.

The series connection has the advantage of simplicity and reduced stress on the existing boilers. However, it is less efficient if the oil fired units are operated infrequently. In small systems, the installation of a stack damper on the existing oil boiler can serve to reduce the standby losses.

5.6 Storage and Handling

In the overwhelming majority of wood fuel systems it is the handling and storage of wood fuel that creates the most severe problems. In any design of a wood heating system more attention should be placed on materials handling than any other area.

There are a variety of alternatives to keeping the cost of fuel storage and handling low. Experiments are still being carried out in Canada, the United States and Scandinavia. This section of the report presents some concepts which might be considered.

5.6.1 Roundwood

It is assumed that roundwood is purchased in 8 ft. lengths and delivered to the site by the fuelwood supplier. Roundwood may have to be blocked prior to use depending on the firebox size and storage procedures are similar to that for roundwood use in residences. It is desirable to use pallets to keep the wood off the ground and promote drying of the wood fuel. A principal concern is to minimize the manual labour in reclaiming wood from the pile. Since stoking roundwood units has to be done regularly and, for conventional systems, at night, an intermediate storage near the furnace is required that will store 1 to 2 cords (see Figure 5.4). In larger roundwood units such as the ECIL design used for tobacco drying, front end loaders can be used to handle the fuel. The extra manual labour required to block, stack, reclaim and feed a manually fed system using between 50-100 cords a year is estimated at 2 hours/cord.

5.6.2 Semi-Automated Woodchip Systems

In the small sizes of wood chip stokers (0.2 MM BTU/hr - 1 MM BTU/hr 60-290 KW) a screw auger transfers fuel from a small surge bin (see Figure 5.5). This surge bin can be filled either manually or by using a front end loader if one is available. This type of system is suitable for a farm type application where someone would normally be working near the equipment. The surge bin storage would be sized such that overnight operation of the equipment is possible. In Table 5.4 the storage volume of wood chips required to supply 12 hours of operation at full load is given for a number of heating loads.

Table 5.4
Surge Bin/Storage Capacity for 12 hrs.

Boiler Size (HP)	Wood Fuel Consumption		
	MM BTU/hr.	Cu. Ft.	Cu. M.
10	0.33	73	2.1
20	0.67	146	4.1
30	1.00	219	6.2
40	1.34	292	8.3
50	1.67	365	10.3

Assumptions: Boiler efficiency 65%, moisture content of fuel 40%, Fuel Bulk Density 16.2 lb/ft³ (259 kg/m³)
Fuel Higher Heating Value 8600 BTU/lb (20 MJ/kg).

The factory supplied storage bin of small systems can often be extended by building an extension. However, it should be noted that wood chips will stick and bridge at the slightest obstruction. Any extension should be a vertical version of the existing bin.

A number of possible configurations for placing the heating system and the storage are shown in Figures 5.5 - 5.12.

One problem is how to optimize the size of the fuel storage building. The ideal size would be such that all fuel is supplied in the fall for the winter heating season. However, this may mean an unacceptably high storage cost. If the wood is being chipped by the owner of the heating plant from his own woodlot using rented chippers then a possibility might be to chip all small diameter material for the first part of the winter. Large diameter material could be stored outside the storage building. At a suitable time during the winter a chipper could be rented and the roundwood chipped directly into the storage.

An alternative to the above, if chips are purchased directly from a wood chip supplier, would be to contract for a number of deliveries per year using an existing or rented front end loader to place the material into storage.

5.6.3 Storage and Drying of Wood Chips

Since wood chip stokers can be damaged by foreign material care should be taken to ensure that metal objects, scrap lumber and dirt do not get into the fuel. This means that a paved floor is required wherever wood chip fuel is being dumped and reclaimed. However, the storage building itself can be a simple pole barn. The important consideration is to have some form of cover to keep the rain and snow off the pile. Good ventilation is desirable since wood chip fuel in storage will start to heat

TYPICAL PLANT LAYOUTS

Figure 5-4

Roundwood System with Outside Fuel Storage.

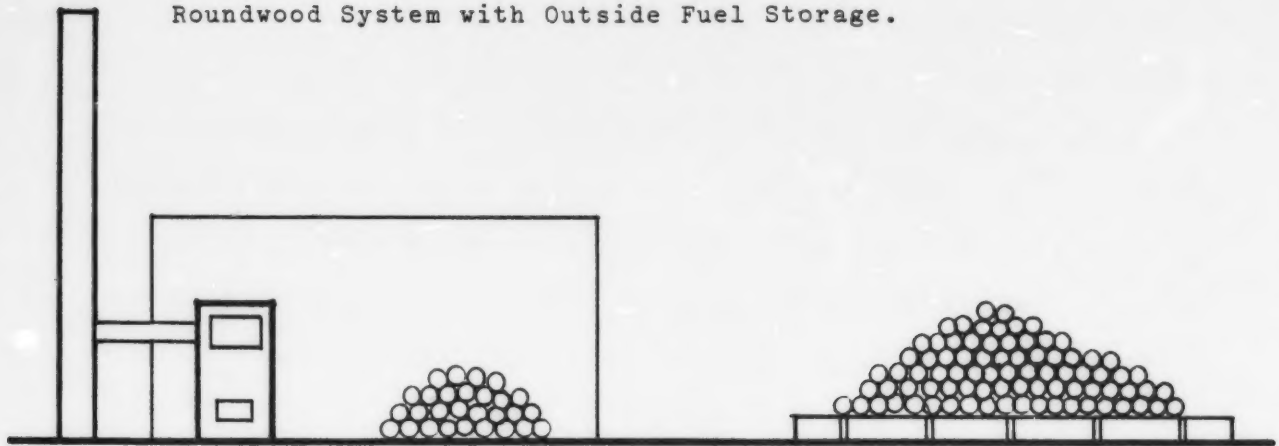


Figure 5-5

Stoker Woodchip System with Manual Loading.

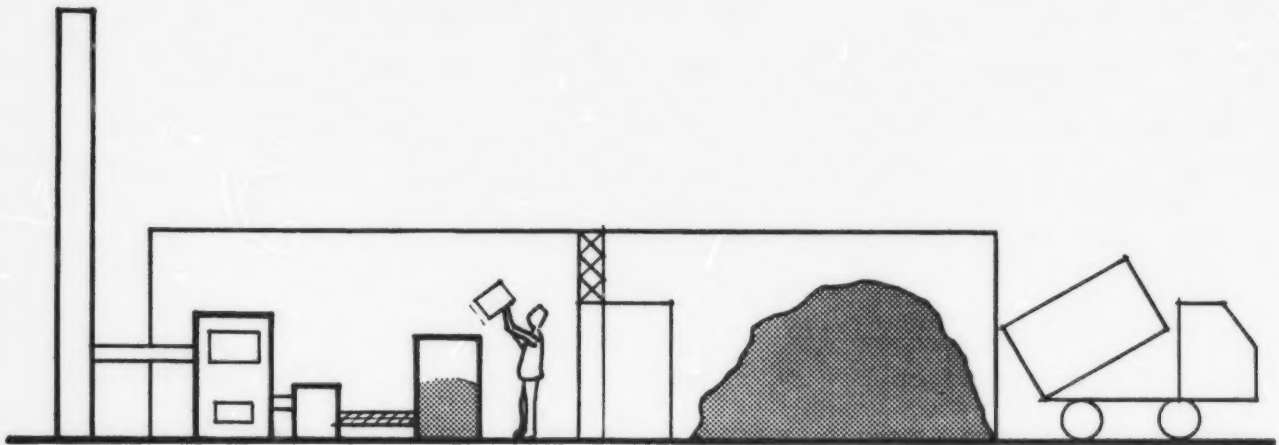


Figure 5-6

Stoker Woodchip System with Separate Bulk Storage.

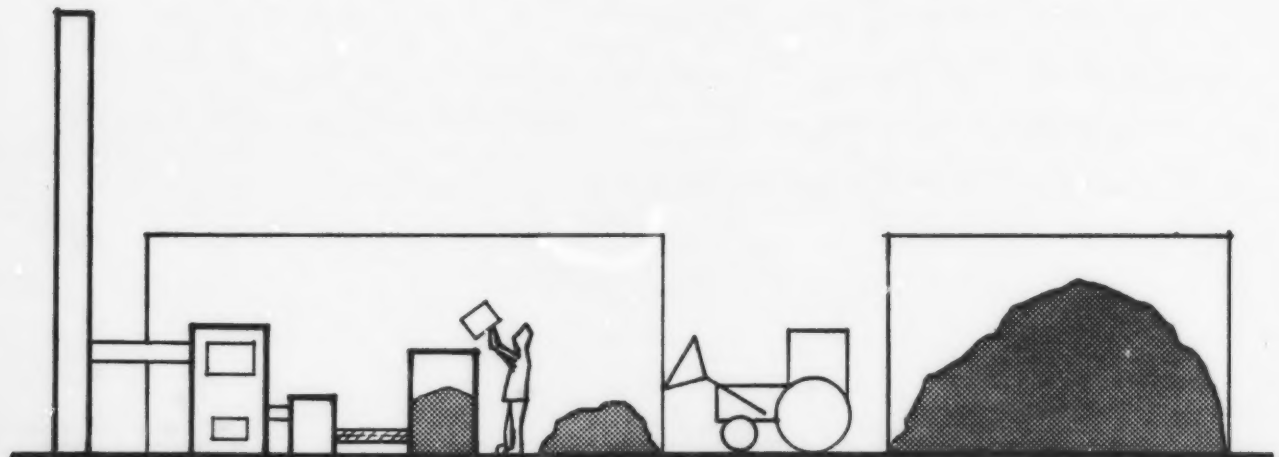


Figure 5-7
Gravity Fed Woodchip System with Manual Loading.

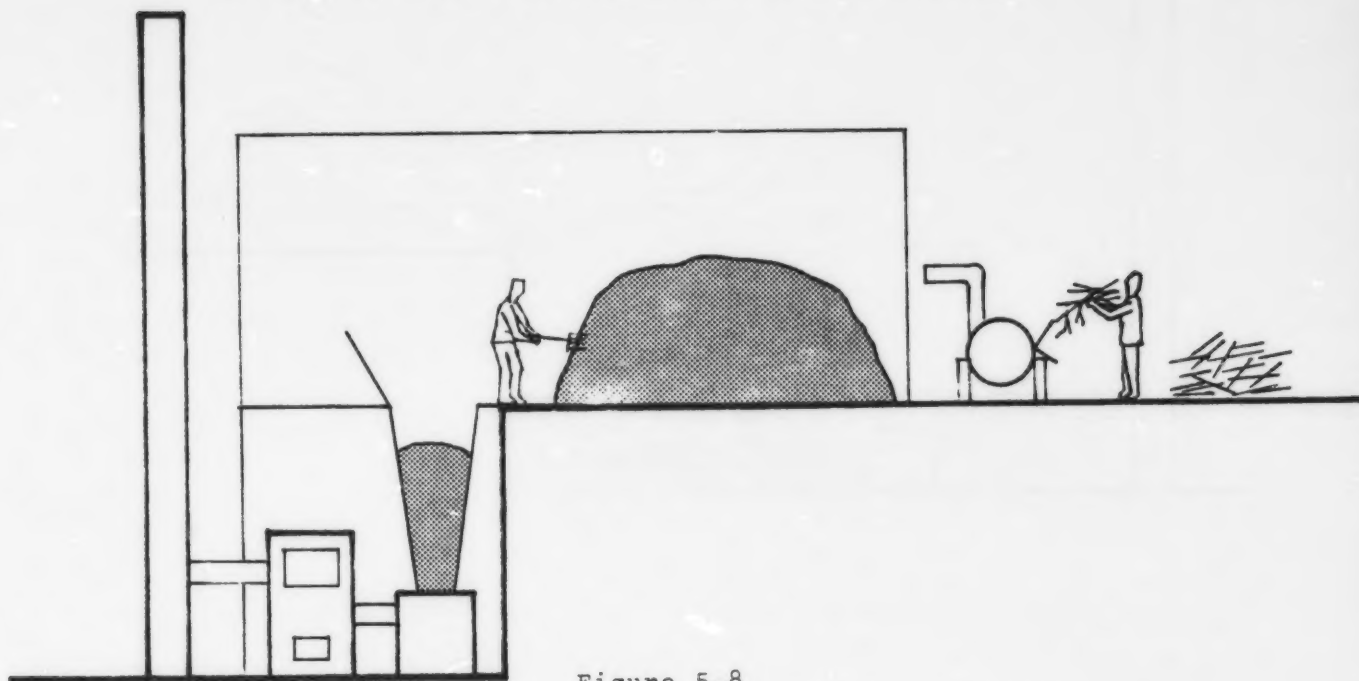


Figure 5-8
Gravity Fed Woodchip System with Mechanical Loading.

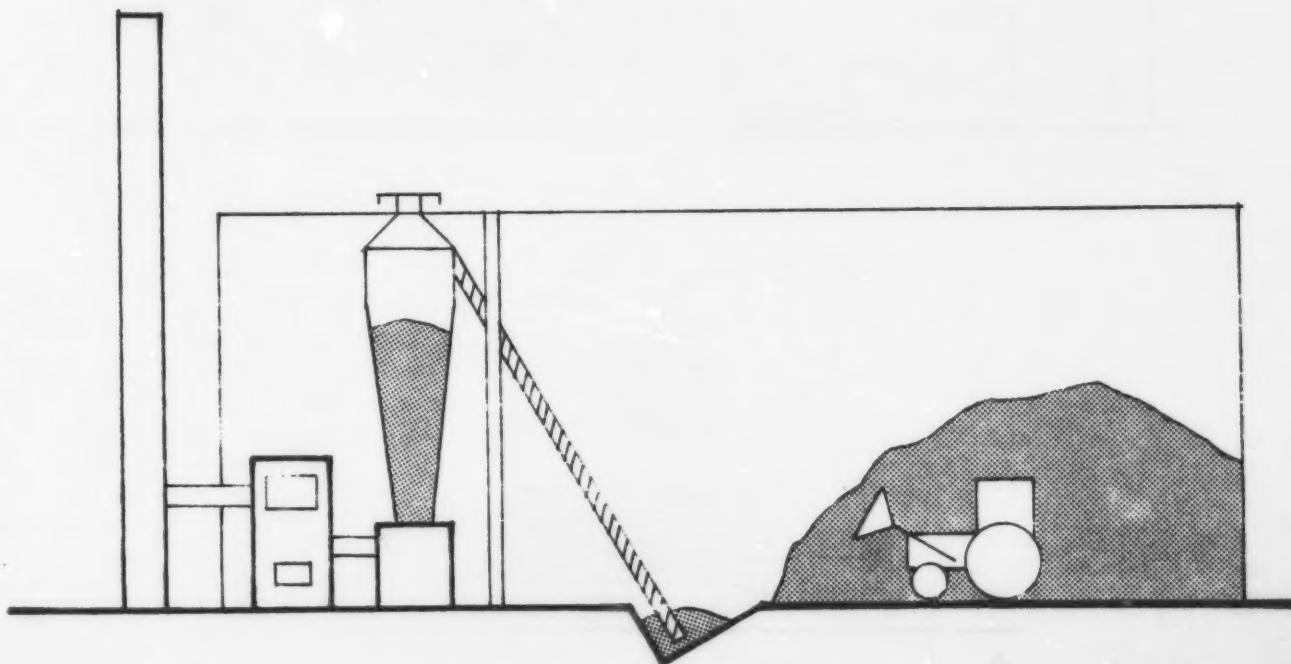


Figure 5-9
Stoker Woodchip System with Silo & Scrapers.

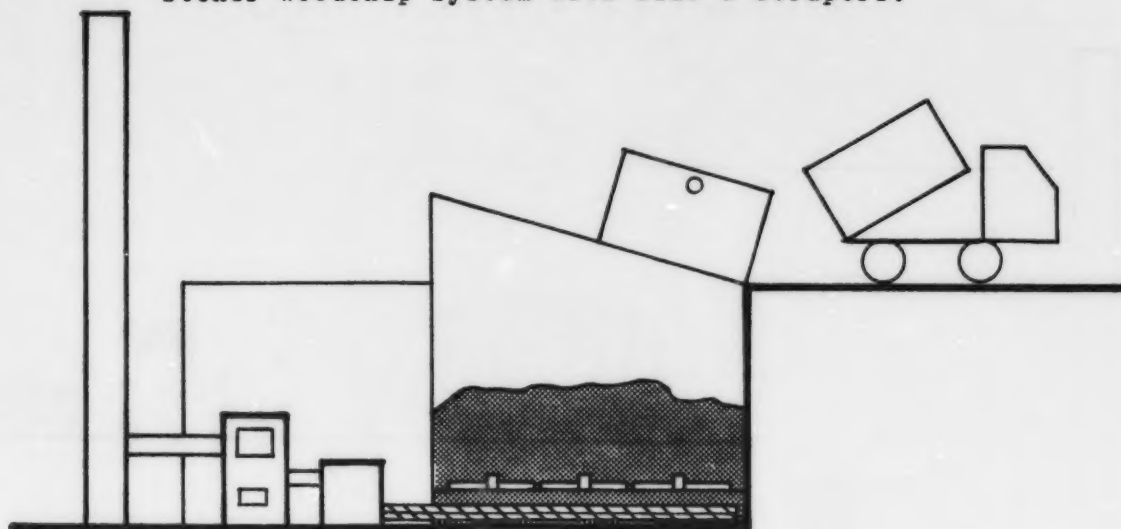


Figure 5-10
Prefabricated Woodchip Plant with Side Dumping Wood Chip Truck.

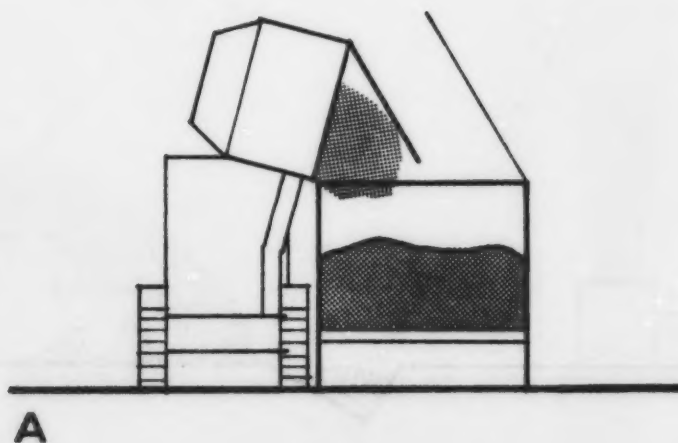
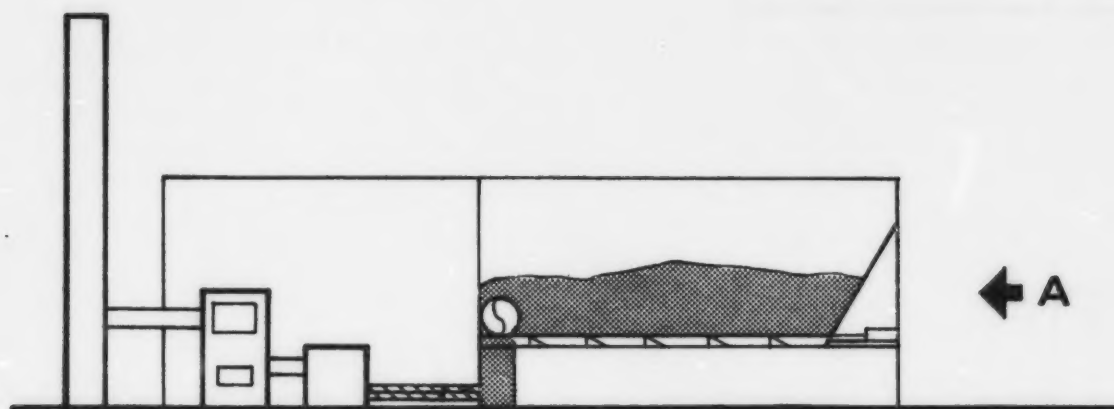


Figure 5-11
Stoker Woodchip System with Top Loaded Silo.

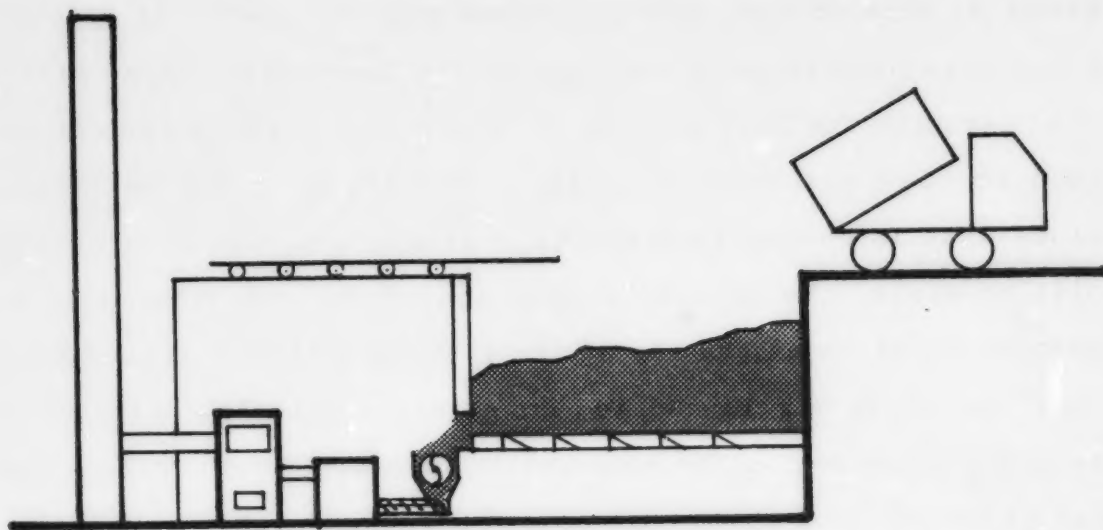
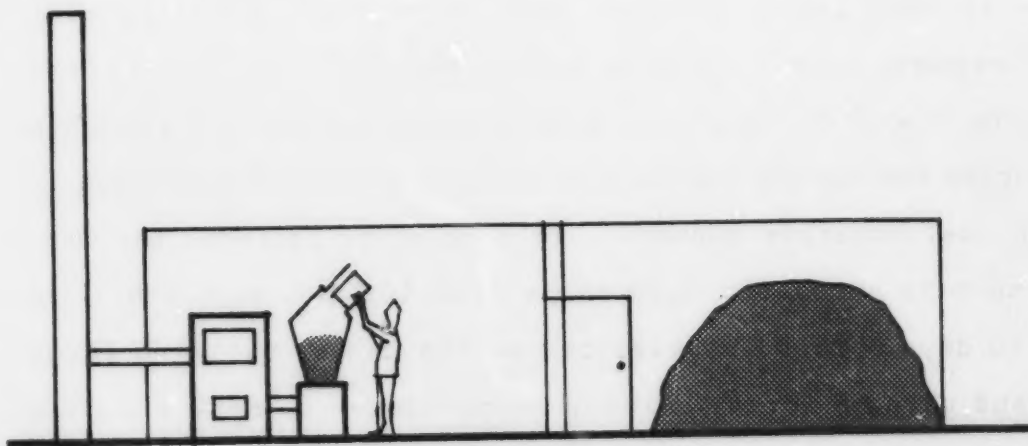


Figure 5-12
Gravity Fed Woodchip System with Manual Loading.



due to biological action if the moisture content is greater than 30%. This heating action can be used to advantage to reduce the moisture content of the fuel before it is burnt. A cost effective form of fuel drying involves placing lengths of plastic field tile pipe through the base of the fuel pile. These pipes are placed in the fuel pile as it is stored. A small fan can be used to blow air into the pile. The fan need not be large, since what is needed is a low flow of air into the base of the pile to assist the natural convection of air through the pile. Adequate venting at the top of the storage building will ensure that the moist air is carried outside the building before the moisture condenses on the roof and falls back into the pile. The use of boiler room heated air passed through the chip pile is not to be recommended. The reason is that ice forms in the pile as the heated and water saturated air is cooled by the fuel pile.

5.6.4 Outside Storage

The uncovered storage of wood fuel chips on an outside pad is not to be recommended in the P.E.I. climate unless the storage volume is very large, greater than 3000 tons. With the high winds experienced in P.E.I. the likelihood of tarpaulins surviving a winter is poor. Even outside storage of woodchip fuel during the summer months will result in a steady increase in average fuel moisture content. This moisture increase has been shown to take uncovered wood chips from 42% M.C. to 52% M.C. in about 40 days. This increase can be reduced by building large piles and using a forest skidder or bulldozer to make the pile conical in shape so that it sheds water.

5.6.5 Delivery of Fuel to Automated Systems

The definition of a fully automated system as compared to a semi-automated one is probably more a function of the relationship between the fuel supplier and the owner of the combustion system than the equipment differences. In the semi-automated systems the owner of the plant ensures that the surge bin storage feeding the heating system is kept filled. The owner is also considered available to respond to fuel feeding problems on an 'as required' basis. In the more automated systems a contract supplier would haul fuel from a remote storage site to the combustion site on a more or less regular schedule. These sites would tend to be institutions, commercial establishments and industries. A prime concern with these types of establishments is that the wood heating system should be visually acceptable and that delivery of wood fuel not interfere with their normal operations.

A number of possibilities exist for the design of fuel for this type of site.

a) Fuel is delivered in dump trucks with built up sides and dumped through a hatch into a fuel silo. The fuel silo has a scraper system driven by hydraulic cylinders. These scrapers are fashioned as thin prisms (see Figures 5-11, 5-12) and as they move backwards and forwards under the fuel pile they bring the wood chip fuel up to the boiler auger system. This type of fuel unloading system is well proven and reliable.

However in the smaller size systems under consideration the cost of a specially built storage and boiler room can be

considerable. A recent report(ADI) estimated that heating systems for a large school might cost \$203,000. The cost breakdown was:

Site works	\$20,000	10%
Fuel Storage bin and Boiler Room	\$90,000	44%
Boiler & Auxiliaries	\$60,000	30%
Piping and Electrical	\$ 8,000	4%
Engineering and Contingencies	<u>\$25,000</u>	12%
	\$203,000	

The equipment cost is only 30% of the total project cost and the high costs of design and building tend to significantly affect the system economics.

b) An alternative for systems in the 20-70 BHP (200-700 KW) range is to standardize the boiler room and fuel storage design. The boiler and materials handling system is packaged into a prefabricated building. A project using this concept has been installed at the Centre d'Education Evangeline, Abrams Village.

The container complete with storage is set on a simple concrete foundation and piping connections made into the existing oil fired hot water boiler. The costs for this system are:

Portable Building Plant	\$150,000
Foundation	5,000
Piping and Power Connection	11,000
Crane, Engineering, Contingency	<u>8,000</u>
	\$174,000

The concept would use two containers for larger systems. One container contains the heating system, the other the fuel storage.

5.6.6 Storage Size

The optimum on-site fuel storage volume for fully automated systems depends on several things. The first is the size of the system and the fuel use at peak demand. If it is assumed that the system has been sized according to criteria outlined in Section 5.1 then the system will be working at maximum capacity for significant lengths of time. The storage requirements for 24 hours can be derived from Table 5.4.

The size of the vehicle transporting the wood fuel is important; a minimum storage size would be twice this transportation capacity.

The question of access to the fuel storage bin should be considered. It is suggested that discussions be held with prospective fuel wood suppliers to ensure that their delivery costs are not affected by poor storage design. The economics of wood heating systems are critically dependent on delivered fuel cost and therefore fuel storage should be designed so that fuel delivery is quick and trouble free even in the worst of conditions.

5.7 Maintenance of Wood Fuelled Systems

Most wood fuelled equipment is ruggedly built and should require relatively little preventative maintenance. A wood chip system should have supplied with it, by the equipment supplier, a maintenance schedule that should be followed to keep maintenance costs low.

The most common maintenance activity will be to clean the boiler tubes to avoid wasted heat being discharged up the stack. The inclusion of a temperature probe in the stack is very useful in determining when the boiler tubes should be cleaned.

6.0 Current Government Assistance Programs

6.1 Rationale for Government Involvement

Both the provincial and the federal government are promoting the use of waste wood as fuel in P.E.I. The reasons for this are as follows:

- a) The forest lands on P.E.I. require reforestation and a major barrier to this work is the lack of any market for the low quality trees that characterise most of Prince Edward Island's woodlots. The installation of a number of wood fuel sites would assist in the forestry objectives of the provincial and federal governments.
- b) Although oil supplies from offshore are currently plentiful most predictions indicate a tightening of supplies that would indicate an upward movement in fuel prices around 1990. Since P.E.I. has an alternative fuel source in the form of waste wood the provincial and federal governments wish to promote the use of wood fuel in the commercial and industrial sector as an alternative to light fuel oil.
- c) Supplying wood fuel rather than importing fuel has a beneficial effect on the provincial economy. It appears that about 90 cents of each dollar spent on wood fuel remains in the local economy whereas only 10 cents remain in the case of fuel oil.

6.2 Government Programs

6.2.1 Alternate Energy Development Program

The principal incentive program for organizations thinking of investing in a wood fuelled heating plant is this program administered by Energy, Mines and Resources Canada. Although other programs such as the FIRE program will assist in wood fuel conversions, the AEDP program has a larger contribution than FIRE. A sample application form is provided in the Appendix to this report. The program is managed by Energy Mines and Resources Canada, Brecken-Yates Building, Harbourside #1 Charlottetown, (566-7373).

The program will support wood fuel installations for new or existing buildings in the institutional, industrial or commercial sector. The support level is geared to the system payback. Projects will receive support to reduce the payback to three years. Maximum support is 62.5 percent of project costs. Projects that have paybacks of less than 3 years and more than 8 years are ineligible.

Items which can be supported under the program include:

- Fuel Processing, Handling & Storage Equipment
- Transportation Equipment
- Buildings & Site Preparation
- Boiler, Burner or Furnace
- Engineering & Project Management

Part 7: How to Assess a Project's Economic Attractiveness

7.1 Introduction

While all potential converters to wood fuel are concerned with saving money, each organization will assess economic attractiveness of a wood fuelled system from its own perspective. Some of the differences in perspective among organizations that can affect the economic analysis include:

- | | |
|--------------------------|--|
| Tax Treatment: | Public and private non-profit organizations realize all savings while businesses are taxed on the additional profit resulting from the reduced costs of operation. |
| Depreciation: | Capital cost allowances for the investment in building and equipment can have a significant impact on business cash flows. |
| Budgeting Procedures: | Some organizations receive budgets based on payment of expenses incurred and have little incentive to reduce energy costs. Others benefit directly from the achievement of lower operating expenses. |
| Availability of Capital: | Due to budgeting procedures, financial position or other factors, some organizations have limited access to capital for investment in cost reduction measures. |

**Investment
Criteria:**

Businesses tend to require shorter paybacks (higher rates of return) than public organizations, which may include social as well as economic costs and benefits in their decision-making process.

Risk:

Organizations differ in their ability to accept and manage risks of new investments. It should be noted that it may be possible to transfer risks associated with conversion to wood fuel through insurance and other measures.

In the discussion which follows, an approach for assessing the economic attractiveness of possible conversion investments will be utilized which attempts to allow for the differences listed above. The method of analysis to be outlined is based on the preparation of estimates of the amount and timing of cash flows that would occur if an investment in wood fueled heating equipment were to be made. In essence, these estimates consist of the identification of the positive and negative effects on an organization's chequing account if the investment in wood fired equipment were made. For example, the reduction in fuel costs resulting from the replacement of oil with wood is a clear benefit to the organization and is therefore a positive cash flow, often called a cash inflow. On the other hand, expenditures for the capital cost of the equipment and higher labour costs to maintain the wood burning unit are examples of negative cash flows (termed cash outflows). After all relevant

cash flows have been estimated, it is possible to judge how attractive the investment would be. For example, every organization would likely invest \$50,000 to enjoy a cash inflow of \$25,000 annually while few would make such an investment to save \$1,000 annually.

The remainder of this section of the guide discusses this approach to assessing the financial attractiveness of possible investments in wood fuelled heating equipment. Section 7.2 discusses the approach for estimating savings in fuel costs and the net savings that will be realized after consideration of any changes in labour, electrical and other operating costs. Section 7.3 discusses the approach for estimating the capital investment involved while Section 7.4 outlines the method for calculation of project payback and other measures of financial attractiveness. In Section 7.5 sources of capital are briefly reviewed. Section 7 is completed with an example of the assessment of economic attractiveness of a conversion investment.

7.2 Fuel Savings and Net Savings

Estimates of fuel cost savings are based on estimates of the amount of oil to be displaced by the amount of wood which will produce the equivalent amount of useful heat. To prepare these estimates, it usually proves useful to:

- 1) Identify current usage of oil by month and for the entire heating season. Where possible, this information should be normalized on a degree-day basis.

- 2) Estimate the quantity of oil to be replaced, typically 75% to 90% of total current consumption. Most likely, wood will not displace either the infrequent peak heating requirements that occur or the very low requirements at the beginning and end of the heating season.
- 3) Estimate the quantity of wood required to displace the oil. Factors which must be considered include the moisture content of the wood fuel (the amount of fuel required increases significantly with greater moisture content) and the average efficiency of the combustion equipment for the entire heating season (not only in the most efficient operating conditions). For roundwood, the difference in density of hardwood and softwood must be taken into account (although the available energy per pound of wood is similar for all species).
- 4) The price of the oil displaced must be forecast. Many people see little reason for oil to increase in price faster than the overall inflation rate for the next few years.
- 5) The price of the wood to be purchased must be forecast. Because of the range of possible sources and forms, these prices will vary considerably from one project to the next.
- 6) Estimates of fuel savings are made by subtracting the cost of wood required from the value of the oil to be displaced.

Wood fuelled systems typically incur higher operating costs than are incurred with conventionally fuelled systems. The major areas of operating costs that may be affected are:

- 1) Labour: In some organizations employee time associated with handling wood fuel and maintaining the system is small and no extra hours are worked. For others, the extra labour requirements represent additional time and the associated increase in labour expense should be estimated.
- 2) Repairs and Parts: Although wood fuelled equipment has been shown to be reliable, estimates of the cost of repairs and replacement parts are necessary.
- 3) Electricity: For woodchip burningsystems, electrical costs will be greater than the savings enjoyed by not operating the oil burning system. The net increase in electrical expense should be estimated.
- 4) Insurance: Estimates of any increased costs for insurance (fire, damage, boiler, liability) are necessary.

The net savings to be realized from the operation of the wood fuelled equipment are calculated by subtracting the increase in estimated operating costs from the estimate of fuel savings.

It can be noted that for a business, this estimate of net savings is equivalent to an estimate of change in profit before the effects of depreciation and tax are taken into account. Estimates of depreciation, a non-cash expense, must be developed based on the break-out of the capital investment into the applicable capital cost allowance classes. For a small business

on P.E.I. in a profitable position, taxes of 25% of net savings after depreciation (capital cost allowance) would have to be recognized as a cash outflow.

7.3 Capital Investment

The major components of the investment required for conversion to a wood fuelled system are:

- i) Feasibility Analysis: A study of the technical and economic feasibility of conversion alternatives is often desirable to identify the best system suited for an organization's facility. This might cost 2 - 5% of the total system cost.
- ii) Engineering and Design: If a system appears to be feasible, a detailed design and cost estimate for the project will be required. This might cost 8 - 10% of the total system cost.
- iii) Buildings and Equipment

A variety of types of equipment may be involved and the full range of costs including installation and site preparation should be estimated where appropriate. It is strongly recommended that these estimates be based on formal quotations from suppliers. Estimates may be required for:

- Fuel Processing, Handling and Storage Equipment
- Transportation Equipment
- Buildings and Site Preparation
- Boiler, Burner or Furnace
- Engineering and Project Management
- Contingencies

It should be noted that contributions are available under EMR's Alternate Energy Development Program toward certain of the capital costs.

The investment in a wood-fired boiler may defer the replacement of an oil-fired boiler for many years. In this situation, only the additional investment required for the wood fuelled system (that is, the incremental cost of the wood-fired unit) should be recognized in the assessment of economic attractiveness.

7.4 Assessment of Financial Attractiveness

The most commonly used measure of the financial attractiveness of a possible investment in a new wood fuelled system is called simple payback. Simple payback is calculated by dividing the after-grant capital cost of the project by the annual net savings. For example, if the investment were \$50,000 and the net annual savings estimated to be \$10,000, the payback would be 5 years.

It should be remembered that, for businesses, net savings should be reduced by any increase in taxes before simple payback is calculated.

Most businesses are prepared to invest in projects with paybacks of up to 3 to 4 years. Non-business organizations are frequently willing to invest in projects with longer paybacks because of the social as well as economic benefits which may result from the project.

For major investments, a more comprehensive financial analysis may be carried out. Such an analysis would be based on estimating relevant cash flows for the life of the project, typically taken to be 15 years. These detailed estimates provide the basis for calculation of the project's internal rate of return (IRR), a measure of the attractiveness which takes into account the time value of money, expected changes in the prices of oil and wood fuel, operational and maintenance costs. A detailed estimate would take into account such things as increases in taxes because of increased profits due to fuel savings as well as tax reduction due to depreciation changes. Many business firms use IRR as an important indicator of the attractiveness of alternative investment possibilities.

7.5 Sources of Capital

Capital for a conversion project may come from a variety of sources:

- i) Contributions: EMR's Alternative Energy Development Program is directly relevant.
- ii) Loans from conventional institutions
- iii) Internally generated funds (business)
- iv) Budget for capital expenditures (public organization)

As well, it is sometimes possible to utilize an outside source which manages the entire project, including fuel supply arrangements, construction and maintenance of the facility and supplying of the capital funds required. In such a situation, the energy user receives some benefit from the savings while the project manager receives a somewhat larger share to provide a return on the capital supplied.

7.6 Example of Financial Assessment

A recent investment in a wood-fuelled system involved a total capital cost of \$160,000. Grants from the federal and provincial government reduced the net investment to \$50,000. In this case, the heating plant was purchased by a wood chip fuel supplier who sold heat (as measured by a BTU meter) to a school at 90% of the cost of heat from oil. For the fuel supplier, the following payback was estimated:

1.	Investment:	At cost	\$160,000
		Less grants	<u>110,000</u>
		Net Investment	\$ 50,000
2.	Net Savings		
2.1	Tonnes burned	600	
		\$/tonne	\$
2.2	Revenue	\$54.00	\$32,400
2.3	Chip Cost	\$25.00	\$15,000
2.4	Maintenance Labour	2.00	1,200
2.5	Electricity (net increase)	1.67	1,000
2.6	Repairs and parts	.50	300
2.7	Insurance	1.33	800
2.8	Administration	<u>4.00</u>	<u>2,400</u>
		\$19.50	\$11,700
3.	Payback:	4.3 years	

Part 8: Successful Wood Fuelled Projects

8.1 Royalty Gardens

In 1983 Mr. Radanovich of the Royalty Gardens Greenhouse, Charlottetown, installed a Franks Piping boiler of 126 KW capacity. This unit uses about 54 cords of hardwood annually to heat 488 m² of greenhouses that are used year round. The installation cost \$24,000 of which \$7,700 was the boiler. Installation costs were \$4,700 while the boiler room cost \$11,400. Hardwood is bought during the late summer for \$60/cord. With no grants the system had a pre tax payback of under three years. However, since a greenhouse has its peak heating requirement at night Mr. Radanovich has to get up every night at 3 a.m. to load the boiler. This frequent maintenance is the price that has to be paid for not having an automatic stoking capability. Mr. Radanovich has recently installed a 500 gallon storage tank that will enable the system to heat the greenhouses over a nighttime period.

8.2 Kings County Memorial Hospital

The Kings County Memorial Hospital in Montague was the first major wood chip installation in the province. The installation was carried out in 1981 and the system has worked well supplying all the heating and laundry needs of the hospital. The schematic of the system is shown in Figure 4.1. The system cost \$413,000 to install and uses just over 2000 tonnes per year of wood chip fuel. The simple payback calculated for the system is 10 years.

REFERENCES

- 1 IEA 1984. Wood Chip Production Alternatives for P.E.I. Report in preparation by IEA Consulting Group, Charlottetown, P.E.I.
- 2 Island Energy Associates, 1981. Wood Chip Fuel for Residential Use. Institute of Man and Resources, Charlottetown. 41 pp and Appendices.
- 3 Peters, D.C. 1982. The Economics of Harvesting Fuelwood Under Four Different Stand Conditions on Prince Edward Island. Information Report M-X-139, Canadian Forestry Service, Ottawa. 8 pp.
- 4 Savage, G.D. and E.J. O'Hara, 1981. Salvaging Logging Residues for Fuel Chip Production. BScF Thesis, University of New Brunswick, Fredericton. 97 pp.
- 5 Resource Ventures Inc. 1983. Survey of Wood Fuel Use in Prince Edward Island. Report prepared for P.E.I. Energy Corporation, Charlottetown, P.E.I. 30 pp.
- 6 ADI Ltd. Regional Determination of Economic Availability of Harvesting Residues. Canada/N.B. Conservation and Renewable Energy Demonstration Program.

APPENDIX

Preheater Systems Available in Canada

<u>System</u>	<u>Company/ Importer</u>	<u>Local Contact</u>	<u>Sizes Available (MM BTU/hr)</u>	<u>Feed</u>
Sasmo	Mountain- /Stream	Corrigan	0.1-2.0	Gravity/ Ram Stoker
Svemo	BDR	Scotia Farm Services	0.25, 0.50	Screw
Tilley	Tilley	---	0.25, 0.2 0.4	Screw
Anga & Varne	KMW	---	0.25-20	Screw
Sylvatherm	Sylva	---	0.17-14	Screw
Conifer	R.W. Gorman	--	0.75-8.4	Gravity
DanTrim	Malvina	Corrigan	0.12, 0.2, 0.32	Screw

Underfeed Stoker Systems

<u>System</u>	<u>Company/ Importer</u>	<u>Local Contact</u>	<u>Sizes Available (MM BTU/hr)</u>	<u>Feed</u>
Northfab	Northfab	----	0.5 - 20	Screw
Vallsta	BDR	Scotia Farm Services	0.68 - 1.0	Screw
Vynke	Apsco	---	1.0 - 36	Screw
FP	Franks Piping	Bevan Brothers		
Passat	Malvina	Corrigan	0.2 - 0.5	Screw

MANUFACTURER'S & AGENTS ADDRESSES

<u>Company</u>	<u>Address</u>	<u>Tel.</u>
Tilley Manufacturing	N. Tilley New Brunswick	506-273-2467
Sylva Energy Systems	519 Richard Street Thunder Bay Ont. P7A 1R2	807-683-6795
Eshland	P.O. Box 8A Greencastle PA 17225	717-597-3196
Trent Industrial Contractors Ltd.	Spruce Lake Industrial Park P.O. 3156, Station B St. John, N.B. E2M 4X8	506-674-1993
R.W. Gorman Associates	200 South Washington Ave. Washburn, Wisconsin 54891	715-373-2632
Robert Bell Industries Ltd.	156 Main Street South P.O. Box 70 Seaforth, Ont. N0K 1W0	519-527-0600
BDR Machinery Ltd.	1104 Fewster Drive Mississauga, Ontario L4W 2V7	416-625-9236
Franks Piping	20 Windsor Road Bramptonville, PQ	819-846-2771
A2SCO Engineering Ltd.	P.O. Box 270 Cremona, Alberta T0M 0R0	403-637-3955
Malvina Inc.	6 Rue Queen Lennoxville, PQ	819-563-3585
Scotia Farm Services	Box 501 Kentville, N.S. B4N 3X3	902-678-7797
KMW	150 White Oak Road London, Ont.	519-686-1771
Northfab Systems (Canada) Ltd.	P.O. Box 202 Stratford, Ont.	519-271-5530
Woodshed Heating Systems (Belmont Metal Works)	Little York, P.E.I. COA 1P0	902-672-2090

WOOD CHIP SUPPLIERS

The individuals or companies listed below have or have recently had an interest in supplying wood chip fuel.

La Co-operative Forestiere, Wellington
Contact: Marcel Arsenault, 854-3465

J. O. Hornby Ltd.
Contact: Jim Hornby, 424-8670

Rodlen Wood Chip Co.
Contact: Arnold Croken, 436-7279

Island Wood Energy, York R.R.1
Contact: Wanson Hemphill, 672-2858

ENERGY, MINES AND RESOURCES CANADA

- Economic and Regional Development -

- Energy Sub-Agreement for Prince Edward Island -

APPLICATION FORM

Alternate Energy Development Program

PART I - GENERAL INFORMATION

Please supply the following information about your organization on a separate sheet of paper under these headings:

1. ORGANIZATION

Legal and/or Corporate Name of Applicant

Mailing Address

Registered Head Office and a brief corporate history of the organization.

2. ACTIVITY OF THE ORGANIZATION

Nature of present activities, location of plant(s), raw materials, processes, products, planned future activities etc.

3. FINANCIAL STATUS

Provide the last two annual financial statements (audited). If a new business venture, provide an opening/current balance sheet as well as a projection of income and expenses for a two year period.

4. PROJECT DESCRIPTION, COST AND FINANCING

Indicate the type and age of facility presently in use and a brief description of project, with layout drawings or sketches, and identification of proposed major components. Source of funds (internal funds, bank loans, new revenue sources as a result of the project, etc.). Indicate if facility or land where project is located is leased. Also state how this project fits into your overall operating strategy and what effect if any the project will have on it.

5. PROJECT MANAGEMENT, DESIGN AND ENGINEERING EXPERTISE

Names of outside consultants, contractors, etc. Extent of internal management and engineering.

6. ENVIRONMENTAL IMPACT

A description of the environmental impact of the proposed project and possible adverse effects of this installation; include description of present method of waste disposal.

7. **BIOMASS FUEL AVAILABILITY**

Type of biomass, e.g., sawdust, shavings, chips, round wood, municipal or agricultural waste; indicate whether generated by applicant or purchased; security of supply for the next five years; etc.

CHECK THE PROGRAM YOU ARE REQUESTING A CONTRIBUTION THROUGH:

WOOD/BIOMASS CONVERSION PROGRAM []

ENERGY FROM WASTE PROGRAM []

PART II - PROJECT DATA

A. **PRESENT FUEL CONSUMPTION:**

Type of Fuel Used	_____
Overall System Efficiency	_____ %
Volume Used per Annum	_____
Current Price	_____
Percentage of Above Fuel to be Replaced	_____ %

B. **BIOMASS FUEL:**

Type of Biomass Substitute	_____
Approximate Moisture Content	_____ %
Annual Volume Required	_____
Annual Volume Available	_____
Delivered Cost per Unit*	_____
System Efficiency of Proposed Equipment	_____ %
Equipment Design Rating	_____

(* May be negative in the case of tipping fees)

C. **CAPITAL COST:**

Fuel Processing, Handling & Storage Equipment	\$ _____
Transportation Equipment	\$ _____
Buildings & Site Preparation	\$ _____
Boiler, Burner or Furnace	\$ _____
Engineering and Project Management	\$ _____
Contingencies	\$ _____
Other	\$ _____
TOTAL	\$ _____

PART II - PROJECT DATA (CONTINUED)

D. ANNUAL OPERATING & MAINTENANCE COST:

	<u>PRESENTLY</u>	<u>EXPECTED</u> (i.e. after project completion)
Operating Labour	\$ _____	\$ _____
Maintenance	\$ _____	\$ _____
Electricity	\$ _____	\$ _____
Fuel*	\$ _____	\$ _____
Other	\$ _____	\$ _____
<u>TOTAL</u>	\$ _____	\$ _____

(* For transportation and mobile equipment e.g. for retrieving biomass.)

E. GENERAL INFORMATION:

Project Estimated Starting Date _____
Estimated Completion Date _____
Location of Proposed Project _____
Name of Person to Whom Enquiries _____
May be Directed _____

DECLARATION BY APPLICANT

To: The Minister of Energy, Mines and Resources (herein after referred to as "the Minister")

- (a) The information given in this application and in the attachments is, to the best of my knowledge and ability, complete, true and correct. I hereby authorize Energy, Mines and Resources Canada to obtain any additional information required from any source for this application.
- (b) I understand that any offer of an incentive contribution will be conditional upon the applicant and project meeting the eligibility guidelines that have been set out.
- (c) I will notify the Provincial Director, Conservation and Renewable Energy Office for Prince Edward Island of any significant change in plans.
- (d) I understand that the amount of incentive contribution that I am eligible for will take account of any other incentive contributions or government assistance given towards the project. The incentive contribution may therefore be based on the net project costs. I will advise the Conservation and Renewable Energy Office for Prince Edward Island without delay if any funding of the above nature have been offered or received.

DECLARATION BY APPLICANT (CONTINUED)

- (e) I hereby certify that an Alternate Energy Development Program Contribution is a significant factor in the decision to proceed with the project. I declare that as of the date of this declaration the project has not started and it is agreed that I will not be eligible for a contribution if any services or goods are ordered before initiation of the approval of a contribution for this project by an authorized representative of the government of Canada.

SIGNATURE OF AUTHORIZED OFFICER

NAME AND TITLE OF AUTHORIZED OFFICER

SIGNED AT _____ THIS _____ DAY OF _____